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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW will be published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Beginning August, 1915, the material for the MONTHLY WEATHER REVIEW will be prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology.*—Results of observations by Weather Bureau observers and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; Tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and Chart No. IX of the North Atlantic Ocean, for August, 1914. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year late. The first issue of this summary and accompanying chart will be found in this number.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions that during recent years were prepared by the 12 respective "district editors" are omitted from the MONTHLY WEATHER REVIEW, but collected and published by States at selected section centers.

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month designated on the title page; hence, the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are especially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belen College, Habana.
The Government Meteorological Office of Jamaica
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASURED AT WASHINGTON, D. C., DURING AUGUST, 1915.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., Sept. 18, 1915.]

In Table 1 are summarized the measurements of the intensity of direct solar radiation made by the Weather Bureau at the American University,[1] Washington, D. C., during August, 1915. The means for the month do not differ materially from the 5-year means published in the Bulletin of the Mount Weather Observatory, 1912, **5**: 182, Table 3. Not much weight should be given to August means, however, as there are generally but few days in this month when the sky at Washington is suitable for radiation measurements. A maximum noon radiation reading of 1.29 was obtained on August 19, 1915, as compared with an absolute noon maximum for August of 1.40.

Skylight polarization, measured at solar distance 90° and in his vertical, with the sun at zenith distance 60°, averaged 45 per cent, with a maximum of 49 per cent on the 19th. This latter is 9 per cent less than the average maximum polarization for August published in the Bulletin of the Mount Weather Observatory, 1910, **3**: 114, Table 16.

TABLE 1.—*Solar radiation intensities at Washington, D. C., during August, 1915.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.										
	0.0°	48.5°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.3°	79.8°	80.7°
	Air mass.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1915. A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
August 4	1.26	1.13									
7		1.01									
8			0.98	0.84							
13	1.18	1.03	0.91	0.82	0.74	0.66	0.60				
18		1.35									
19	1.31	1.07	0.85	0.77	0.68	0.59					
20		1.07									
22				0.98	0.94						
25	1.11	0.97	0.92	0.80	0.71						
26			0.68	0.59	0.49	0.40	0.32				
Means	**1.22**	**1.09**	**0.87**	**0.80**	**0.71**	**0.55**	**(0.46)**				
P. M.											
August 10		1.15									
19		1.20									
Means		**(1.18)**									

[1] For a description of exposures of instruments and details of methods of observation see this REVIEW, December, 1914, **42**: 648.

In Table 2, column 2 gives the daily totals of solar and sky radiation received on a horizontal surface at the American University during August, 1915. The measurements were made with a Callendar recording pyrheliometer as described in the REVIEW for March, 1915, **43**: 100. Table 2, column 3, gives the daily departures from the normals published in the same number of the REVIEW, page 109, Table 4.

The "Percentage of possible sunshine," and the "Average cloudiness," given in columns 5 and 6 of Table 2, have been taken from the records of the observatory at the Central Office of the Weather Bureau. The monthly mean percentage of possible sunshine is 3 per cent below the normal for August.

The above data unite in showing less than the usual number of hours of sunshine, and solar radiation intensities below the normal for the month, during August, 1915. The radiation deficiency was greatest during the third decade.

TABLE 2.—*Daily totals and departures of solar and sky radiation at Washington, D. C., during August, 1915.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily total.	Departure from normal.	Excess or deficiency since first of month.	Percentage of possible sunshine.	Average cloudiness.
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Per cent.*	*0-10.*
August 1	401	− 91	− 91	61	4
2	512	22	− 69	49	5
3	368	−120	− 189	45	7
4	480	− 6	− 195	60	6
5	349	−135	− 330	57	7
6	497	15	− 315	61	5
7	593	114	− 201	82	3
8	438	− 39	− 240	63	4
9	442	− 32	− 272	50	6
10	535	63	− 209	77	4
11	311	−158	− 367	10	9
12	213	−254	− 621	25	9
13	535	71	− 550	88	3
14	557	95	− 455	81	3
15	411	− 48	− 503	38	7
16	517	61	− 442	79	5
17	258	−196	− 638	2	9
18	559	108	− 530	90	4
19	616	167	− 363	100	0
20	489	43	− 320	73	5
Decade departure			**− 111**		
21	189	−255	− 575	18	8
22	378	− 63	− 638	53	6
23	514	75	− 563	96	3
24	517	81	− 482	78	3
25	561	128	− 354	100	0
26	492	61	− 293	99	3
27	187	−241	− 534	4	10
28	80	−346	− 880	0	10
29	380	− 43	− 923	45	7
30	403	− 18	− 941	52	7
31	478	60	− 881	54	6
Decade departure			**− 553**		
Total excess or deficiency since first of year			**−2,081**		

SECTION II.—GENERAL METEOROLOGY.

ON STORM-FREQUENCY CHANGES IN THE UNITED STATES.

By HENRYK ARCTOWSKI.

[Dated: Hastings-on-Hudson, March 3, 1915; Received by Editor, July 15, 1915.]

While, with the assistance of Dobrowolski, Amundsen, and Lecointe, I was making hourly meteorological observations on board the *Belgica*, the ordinary cyclonic explanation of the subantarctic storms seemed most unsatisfactory to me.

I often thought that the barometric depressions of the circumpolar belt of low pressure were more or less regular waves, extended between the South Pacific and polar anticyclonic centers of action, and that these waves traveled eastward around Antarctica, sweeping on both sides the high pressure areas, and that, from the north as well as from the south, anticyclonic crests were wedged between this rotating system of furrows.

Such a wave-motion hypothesis was too old-fashioned **(1)**[1] and at the same time too radical to be discussed on the basis of one year's observations at an absolutely isolated station. Convinced, however, of the fact that our knowledge of atmospheric circulation could be greatly advanced by a systematic study of subantarctic weather conditions, I dared to propose at the British Association meeting at Dover in 1899, the organization for the years of the *Discovery* and *Gauss* expeditions, of meteorological stations installed on the islands between South America, Australia, and the Antarctic continent.

This project came to nothing, but sooner or later it should be realized. The publication of daily weather maps of the Southern Hemisphere, attempted by the Royal Society **(2)**, as well as the elaborate discussions of Meinardus and Mecking **(3)**, give still more weight to this desideratum, and now it appears perfectly clear that an extensive study of the meteorological conditions of the Southern Hemisphere belt of lows would very greatly advance our knowledge of the mode of formation and the orientation of displacement of storms. The interesting and most suggestive memoir of W. J. S. Lockyer **(4)** on the Southern Hemisphere surface-air circulation and Merecki's extensive researches on barometric waves **(5)** also point to the same conclusion.

In the Northern Hemisphere the distribution of atmospheric pressure is more complicated than it is about the Antarctic continent, therefore the lows are greatly deformed and follow different belts of prevalent storm tracks. In Europe, the superposition of all observed tracks of lows gives the impression of a most intricate network. The maps published by Gen. Rykatchew **(6)** may be cited as example.

In North America conditions are simpler. The charts of relative storm frequency published by Finley **(7)** in 1884 plainly show the predominance of the belt of lows along the Great Lakes. The chart of aggregate storm tracks traced by Dunwoody **(8)** from the International Simultaneous Observations taken at Noon, Greenwich time, during the years 1878 to 1887, shows that "the region of greatest storm frequency in the Northern Hemisphere is included in an area which extends from eastern Lake Superior to the Middle St. Lawrence Valley." It may be of interest to notice that the monthly charts by Dunwoody show that "for the spring months the average track of storms over the North American continent is farther south than during the winter season.

Later Bigelow **(9)** classified the different American types of storm tracks and studied their seasonal variations of frequency, but it is only recently that the relations between storm movements and the pressure distributions have been extensively investigated by Bowie **(10)**.

> Of the centers of action that affect the weather conditions of the United States east of the Rocky Mountains, the subpermanent high over the middle latitudes of the North Atlantic Ocean is perhaps most influential. When this is well developed and stable temperatures above the seasonal average are to be expected over the great central valleys and the Eastern and Southern States, and areas of high and low pressure crossing the United States will move in high latitudes and pass on to the ocean by way of the St. Lawrence Valley **(11)**.

As early as 1868 Mohn expressed the opinion that, in general, lows have a tendency to circulate around high-pressure areas, keeping the maximum to the right. In 1870 Prestel found that the lows go clockwise around the highs, and in 1876 Clement Ley pointed out that the center of a barometric depression moves generally at a right angle to the greatest barometric gradient **(12)**.

Coming back, now, to the problem of sub-Antarctic storms, let us extend the experience gained from the study of the daily weather maps to average climatic conditions. We may venture to suppose that wherever there is a more or less permanent area of high pressure with strong temperature and moisture gradients conditions will favor the formation of storms and that these storms will have a tendency to travel around this high-pressure area.

This working hypothesis may be applied to abnormal climatic conditions, e. g., such as I have called the pleionian variations of climate. In the case of atmospheric pressure, in particular, I have shown that when we chart the departures of annual means from quasi-normal values we reveal extensive areas of hyper- and hypo-pressure having more or less resemblance to wave crests and troughs. In case of temperature the areas of positive departures have been called thermopleions. For sake of analogy in the nomenclature of these climatic anomalies we may call the areas of hyperpressure baropleions. In the United States the same baropleion may be observed for several years in succession, but on different areas and with a change of orientation of the crest of highest positive departures **(13)**.

Coming back again to the purely imaginary conception of the sub-Antarctic storms—and remembering the general conclusions gained by Bowie from the study of the United States daily weather maps—we may suppose that a baropleion will have a tendency to act upon atmospheric circulation as the Antarctic Continent does. If so, the baropleions will be surrounded by a belt of waves, accentuated on the side of the steepest gradient of temperature.

[1] Black-faced numbers in curves refer to the list of references at end of the paper.

Leaving completely aside for the present this question of a possible correlation between observed changes in the distribution of storm tracks and baropleions, I will restrict myself in this essay to the study of the variations that occur in the frequency and geographical distribution of lows and shall endeavor to establish the fact that these variations are in harmony with the pleionian cycle.

ANNUAL VARIATION OF THE FREQUENCY OF LOWS.

Utilizing the maps published in the MONTHLY WEATHER REVIEW I counted month by month, for the years 1883–1913, the number of tracks of lows that crossed the 100th, the 90th, and the 80th meridians. If a given low, having a complicated course, crossed one of these meridians twice or three times, as it sometimes occurs, this low was counted for one and not for two or three.

The total numbers of lows that crossed the 100th, 90th, and 80th meridians during the 31 years considered, are 3,044, 2,843, and 2,875, respectively. The monthly totals, divided by 31 (number of years) and reduced to months of 30 days duration, give the following table of means:

TABLE 1.—*Mean frequency of lows crossing meridians 80, 90, and 100 within the United States.*

Meridian.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
100	9.27	9.00	9.08	8.03	7.74	6.51	7.05	6.84	7.61	7.77	8.68	9.21
90	9.61	9.59	9.18	7.42	6.49	5.45	5.99	5.96	6.23	6.58	8.55	9.43
80	9.43	9.49	9.42	7.00	6.62	5.61	6.18	6.34	6.74	7.02	8.23	9.40
Mean..	9.44	9.36	9.23	7.48	6.95	5.86	6.41	6.38	6.86	7.12	8.49	9.35

It is evident that these figures express the average annual variation more correctly than the tables of the number of storms as given by Waldo (**14**) or Bowie and Weightman (**15**). Table 1 shows that on the average the lows observed in the United States are most frequent in January and least frequent in June, and that the frequency in June is 38 per cent smaller than the total for January. Of course the figures of Table 1 give a greater frequency of lows than would result from counting the waves registered by a barograph at some station, and this for the simple reason that not all the lows crossing the meridian north or south of that station influence the area where the station is located. This fact does not greatly affect the amplitude of the annual variation as given above.

It is therefore of interest to compare these figures with the results obtained by counting the barometric waves recorded at given stations. In the case of the *Belgica* observations I obtained (**16**), counting the waves of a minimum amplitude of 5 mm., a mean duration of 83 hours for the months May–July and of 201 hours for November–January, or 8.9 and 3.7 waves per month, respectively. This gave for the southern summer months 41 per cent of the number of lows for the winter months. Table 1 gives for December–February in the United States a mean of 9.38 lows and for June–August 6.22 per month, which makes the number for the northern summer 88 per cent of that for the winter. The annual variation of the frequency of lows must, therefore, be very much more accentuated in the Antarctic regions than it is in the United States.

The interesting fact, however, is that the frequency variation of barometric waves is not everywhere characterized by a simple oscillation showing a well-pronounced minimum during the summer months. For example, in Warsaw the mean duration of the waves, expressed in days and fractions of a day, is, according to Merecki (**17**):

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
5.7	5.7	5.5	5.7	5.8	5.8	5.6	5.7	5.5	5.3	5.7	5.7

This table shows a maximum frequency of waves in March and another maximum in October, a minimum during the winter and a more pronounced minimum in May and June.

Now, tracing from Table 1 the curve of the mean frequencies of lows observed in the States (*a* in fig. 1) we notice that the figure 9.23 for March, which seems too high, as well as the figure 5.86 for June, which seem too low, may have been influenced by the superposition of a double oscillation, similar to that observed in Warsaw, upon the simple normal oscillation.

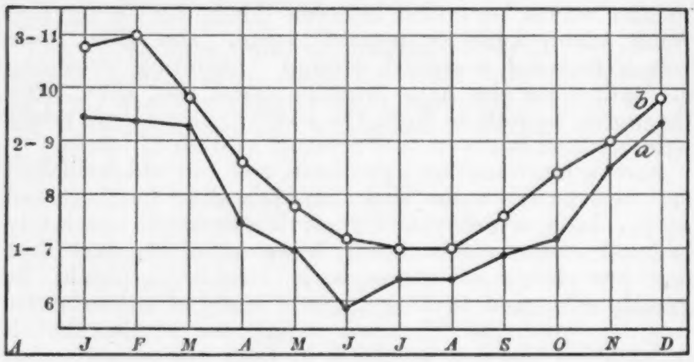

FIG. 1.—Curve of mean frequencies of lows in the United States. (Curve *a* and right-hand scale.)

Curve of mean meridional temperature gradient (°F) in the United States, based on Bartholomew's Atlas of Meteorology. (Curve *b* and left-hand scale.)

A further study of these slight anomalies, examined year by year, would certainly be of some interest. The second curve (*b* in fig. 1) proves it very well. This curve represents the monthly values of the mean temperature gradient (°F.) in the United States. The figures have been obtained from the monthly charts published in Bartholomew's Meteorological Atlas. The distribution of the isotherms crossing the 100th, 90th, and 80th meridian is very regular, so that it is sufficient to take the differences of the means for the 50th and the 30th parallel, and in the case of the 80th meridian, the differences between the crossing of Montreal River and the latitude of Cape Sable. The totals of these differences divided by 61 give the following figures for the mean meridional gradient per degree of latitude:

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
°F.	2.9	3.0	2.4	1.8	1.4	1.1	1.0	1.0	1.3	1.7	2.0	2.4

The great similarity between the curve (*b* in fig. 1) expressing these figures graphically and the frequency curve of lows (*a* in fig. 1) shows that a correlation between the gradient of temperature and the occurrence of storms may be admitted. It seems to be a question of gradient. It can not be that the storms are less frequent during the summer simply because temperature is higher. Merecki's figures for the annual variation of the barometric waves observed in Warsaw show indeed that there the

lows must be less frequent[2] during the winter as well as during the summer. It must be the same[2] through all Russia and Siberia (**17b**). The table of "relative frequency of storms in various seas for different months of the year" compiled by W. Doberck (**18**) shows also great regional differences. It would therefore be of some interest to study the problem more in detail.

TABLE 2.—*Mean temperature observed on board the* Belgica *and mean duration of the barometric oscillations.*

Period.	Mean temperature.	Duration of oscillation.
	°C.	Hours.
February-April	− 7.28	138
May-July	−15.24	83
August-October	−12.58	129
November-January	− 3.45	201

In the case of the *Belgica* observations Table 2 shows that the agreement between temperature and the mean duration of barometric waves is perfect. This may be due to the fact that on the open sea north of the Antarctic circle the temperature is increasing very rapidly at the time when it is cold on the ice, whereas during the summer the temperature gradient is small.

LATITUDE DISTRIBUTION OF LOWS.

There is a great advantage in employing the numbers of barometric waves observed at individual stations, instead of the frequency of lows of the weather maps, both because of greater precision and also of the regional differences in the distribution of lows. We will see now what these differences are.

According to the latitude considered the annual variation in the frequency of lows may be very different from that of the mean values of a given meridian.

The maps accompanying the recently published report of Bowie & Weightman (**11**) demonstrate this fact very clearly. The statistics of Bowie & Weightman's memoir favor an investigation of the annual displacements of the zone of greatest frequency of lows, but as that report was published after my computations were finished I regret that I can not here discuss that problem more fully.

The figures for the 100th and 80th meridians, which I collected from the MONTHLY WEATHER REVIEW maps, may serve as an illustration of a method of research which seems especially suited to pedagogical purposes.

Taking the monthly totals of the numbers of lows that crossed the 100th meridian during the years 1883–1913 between the 55-50th, 50-45th, . . . 30-25th parallels, respectively, I plotted these figures in columns and drew into this table lines of equal frequency; the resulting diagram is shown in figure 2. A more accurate illustration of the annual variation could be obtained by equalizing the monthly values and expressing the numbers in per cent of the total number of lows; but for my present purpose this is not necessary. The inspection of figure 2 shows at once that along the 100th meridian three types of distribution of frequency of lows are distinguishable, viz, the July-September type, the November-January type, and the March-May type. The months of June, October, and February are transitional.

[2] The forecasters of the Weather Bureau feel some doubt of the correctness of this inference.—C. A. Jr.

In August there is a progressive decrease in the numbers of observed lows from the north toward the south. December shows a maximum in the north, another maximum on the 35th parallel, and a secondary minimum between the two maxima. In April the maximum is well pronounced and occurs north of the 35th parallel.

Along the 80th meridian the conditions, as figure 3 shows, are entirely different. This is partly because of the deflecting action of the Appalachian Mountains. October shows a slightly accentuated secondary maximum between 30°–35° latitude, but with this exception the greatest frequencies are observed north of the 45th parallel all the year through. The ascent is steepest in July, when immediately below the figure 125 we notice only 45 lows observed between 45°–40° latitude. During the winter and the spring, particularly in February and in March, the lows have a tendency to travel farther south than during the summer months.

The high figures for latitudes 20°–25° in August, September, and October confirm Poëy's statistics of cyclones observed at Havana (**19**). A. Poëy found that 67 per cent of the observed cyclones occurred during these months.

THE ANNUAL MAXIMUM AND MINIMUM OF FREQUENCY OF LOWS IN DIFFERENT LATITUDES.

There is a radical difference between the annual changes in the distribution of lows along the 100th and the 80th meridians, which fails to appear on the preceding diagrams. This difference concerns the latitude shift of the time of occurrence of the annual minimum and maximum of frequency of lows. In other words, the minimum and the maximum of the annual variation do not occur in the same months in different latitudes; they occur earlier or later in the year, according to latitude, and the character of this displacement along the 80th meridian is entirely different from what it is along the 100th.

In order to demonstrate this fact more plainly than would be possible with words I reproduce in figures 4 and 5 the monthly departures from the averages, as given in the first column of figures.

We see in figure 4 that along the 100th meridian the annual maximum of frequency of lows occurs in February near the 30th degree of north latitude, in March between 30° and 35°, in April between 35° and 40°, in July near the 45th parallel, in August between the 45th and 50th, finally, in October or December, between 55° and 50° or north of the 55th parallel. The minimum occurs in June between 25° and 30°, in July between 35° and 30°, in August between 40° and 35°, in December north of the 40th, in February between the 50th and 45th, and in April north of the 55th parallel. The maximum as well as the minimum are therefore displaced northward as the year advances. Along the 80th meridian (fig. 5) we notice also a well pronounced displacement, but it is directed southward. Here the phenomenon is, however, more complicated, since in latitudes 20°–30° the annual variation has two maxima and two minima.

Comparing these two diagrams with the charts giving the monthly distribution of atmospheric pressure (**20**), or, better, with the monthly departures from the annual means (**21**), one is tempted to admit that, in their annual variation, the storm tracks display a tendency to move clockwise around the shifting high pressure area.

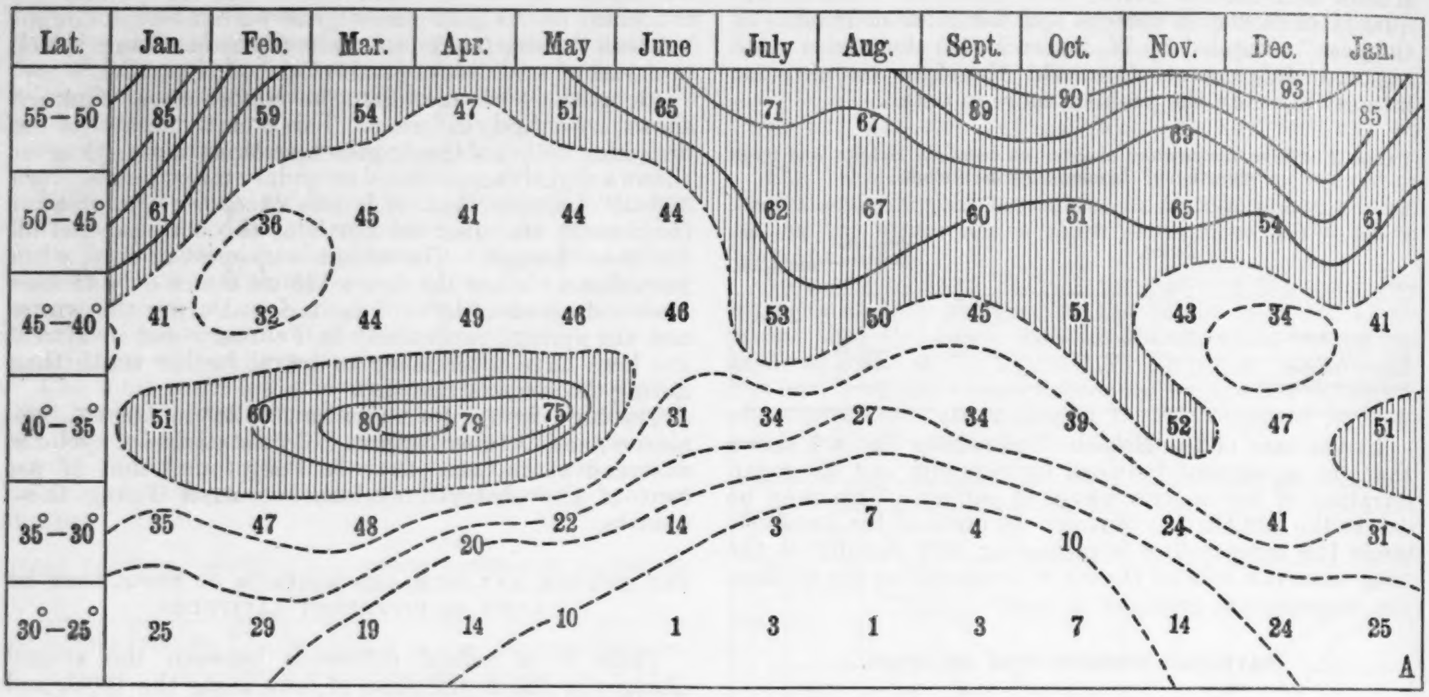

FIG. 2.—Isopleths of lows crossing the 100th meridian from 1883 to 1913, by latitudes and months.

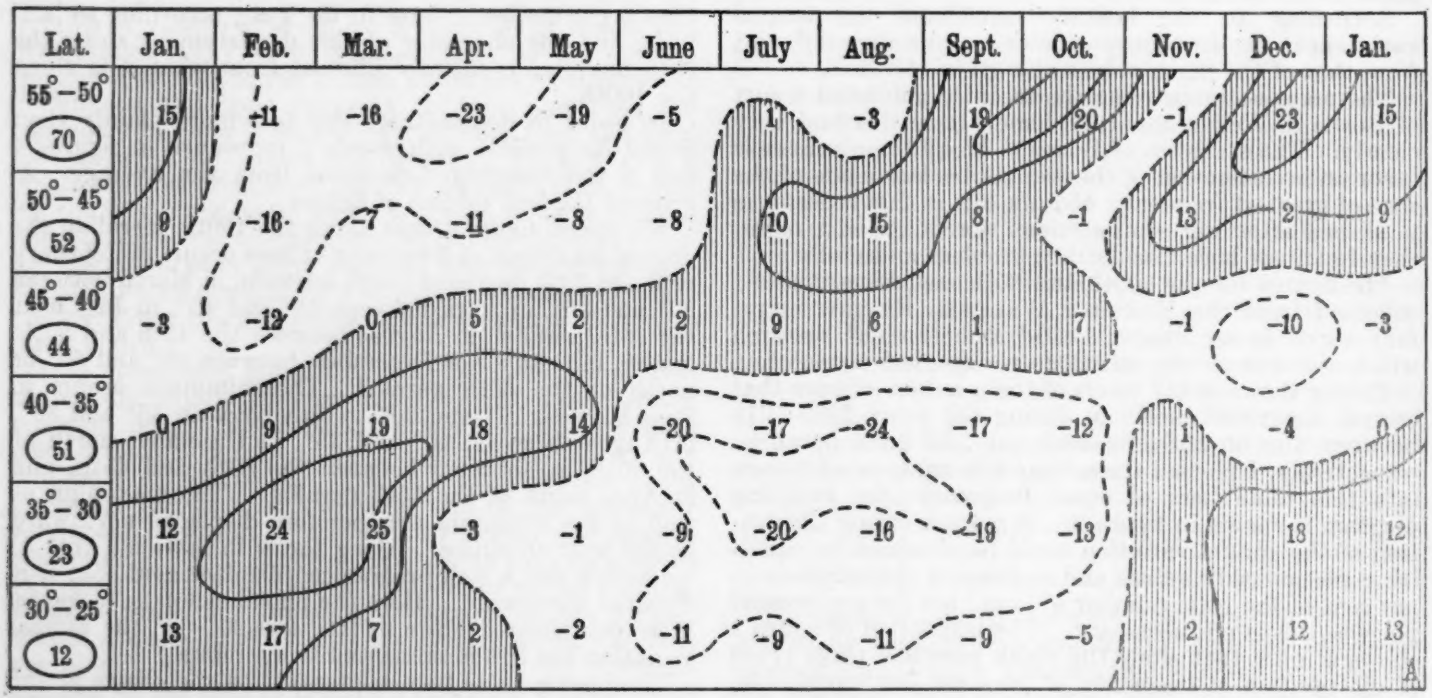

FIG. 4.—Isopleths of monthly departures from the average number of lows crossing the 100th meridian (1883-1913) at different latitudes in the United States. The average number of lows for each latitude zone is stated by the figure in oval at the left; shaded areas indicate seasons of positive departures.

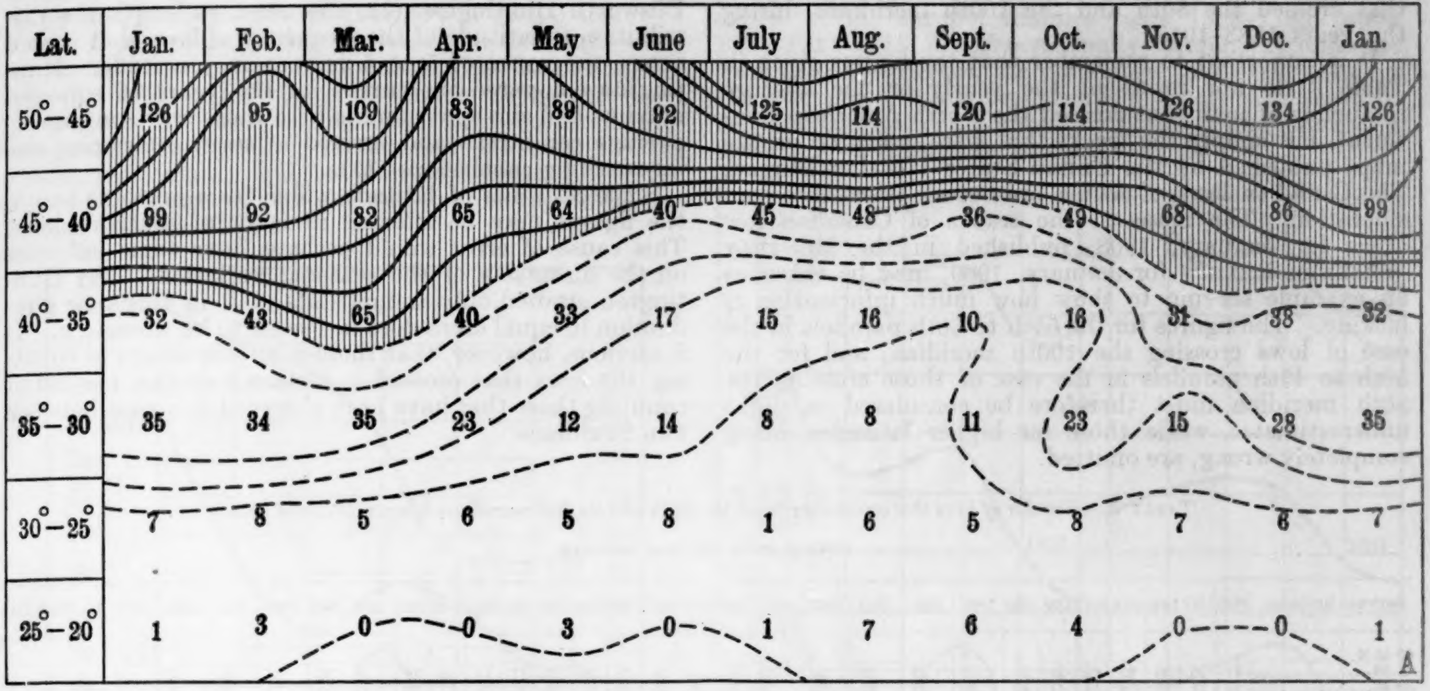

FIG. 3.—Isopleths of lows crossing the 80th meridian from 1883 to 1913, by latitudes and months.

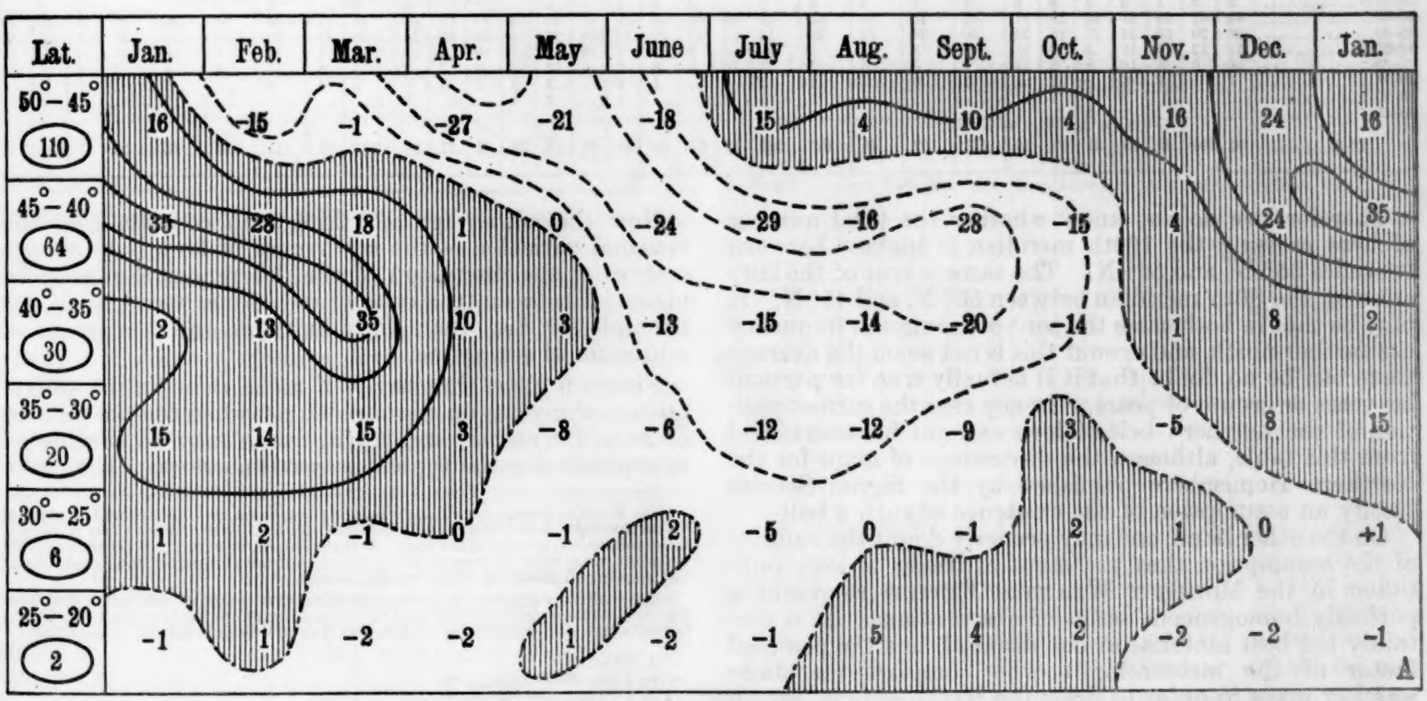

FIG. 5.—Isopleths of monthly departures from the average number of lows crossing the 80th meaidian (1883-1913) at different latitudes in the United States. The average number of lows for each latitude zone is stated by the figure in oval at the left; shaded areas indicate seasons of positive departures.

YEARLY FREQUENCY OF LOWS.

In Table 3 I tabulate my counts of the number of lows that crossed the 80th and the 100th meridians during the years 1883–1913.

It is important to remember that the figures given in Table 3 do not represent the yearly or the average frequency of lows that crossed the North American Continent, but simply the tracks that were indicated on the maps published by the United States Weather Bureau. The Canadian lows, of course, are not all taken into consideration. The maps of the tracks of Canadian low areas for January, 1908, published in the MONTHLY WEATHER REVIEW for January, 1909, may be taken as an example serving to show how much information is lacking. The figures for the 55th to 50th parallels in the case of lows crossing the 100th meridian, and for the 50th to 45th parallels in the case of those crossing the 80th meridian must therefore be considered as slight underestimates, while those for higher latitudes, being completely wrong, are omitted.

Therefore we do not know whether the total number of lows crossing the 100th meridian is highest between latitudes 55° N. and 50° N. The same is true of the lows crossing the 80th meridian between 50° N. and 45° N. It may be that in both cases the zone of maximum frequency lies farther north, and even if this is not so on the average there can be no doubt that it is actually true for particular years or groups of years. In any case the correct position of the northern belt of lows can not be ascertained from this table, although the discussions of maps for the Northern Hemisphere published by the Signal Service justify an assumption of the existence of such a belt.

On the other hand, one may properly doubt the validity of the assumption that the maps of tracks of lows published in the MONTHLY WEATHER REVIEW represent a perfectly homogeneous series of observations. It is certainly the best material at our disposal, but the personal factor of the meteorologist who compiles the daily weather maps in order to draw the tracks of lows has an unquestionable importance, and it is difficult to admit that this personal factor has not undergone some changes and has not influenced, one way or the other, the compilations made.[3]

Utilizing the data collected by Charles J. Kullmer, Ellsworth Huntington (22) discussed at length the distribution in latitude of the frequency of lows that passed across the zones of 5 to 5 degrees in longitude. Huntington compared the curves for the years of sun-spot maxima and sun-spot minima with those representing the average conditions and arrived at most interesting and far-reaching conclusions (23).

Since 5°-zones of latitude widen from north to south, the figures may be affected in favor of southern lows. This cause of error would perhaps have some influence on the discussion of the seasonal variation. But Huntington studied only annual data, and in this case a reduction to equal areas does not seem to be necessary. It is obvious, however, that there is an advantage in counting the lows that crossed a certain meridian instead of counting those that have been observed in a zone between two meridians.

TABLE 3.—*Number of lows that annually crossed the 100th and the 80th meridians between 1883 and 1913.*

LOWS CROSSING THE 100TH MERIDIAN.

Between latitudes.	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913
60-55 N.	....	....	....	....	....	....	1	3	....	....	1	3	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
55-50	21	23	22	27	32	24	25	37	38	36	39	36	37	34	39	32	30	33	17	14	13	26	39	31	25	34	15	19	9	15	18
50-45	15	21	11	18	14	11	25	20	22	23	23	26	23	26	15	19	16	24	21	14	17	22	16	14	24	22	30	31	23	26	18
45-40	17	14	17	14	21	15	16	14	16	19	25	29	19	13	14	12	17	18	23	15	17	19	15	14	15	12	16	13	24	20	21
40-35	18	17	16	18	15	18	17	18	13	17	27	13	10	19	17	15	19	18	20	22	17	21	27	25	20	24	30	25	26	22	25
35-30	6	4	1	8	8	7	9	10	14	14	11	9	5	3	6	9	9	13	9	16	9	14	8	7	10	8	12	8	6	9	12
30-25	4	3	1	9	6	1	4	6	4	2	1	7	4	....	4	6	8	6	5	....	7	2	10	5	11	6	5	9	4	....	8
25-20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....
Total	**81**	**82**	**68**	**94**	**96**	**76**	**97**	**108**	**107**	**111**	**127**	**123**	**98**	**95**	**95**	**93**	**99**	**112**	**95**	**81**	**80**	**104**	**115**	**96**	**106**	**106**	**108**	**105**	**92**	**92**	**102**

LOWS CROSSING THE 80TH MERIDIAN.

Between latitudes.	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913
55-50 N.	3	3	1	3	3	3	6	7	7	3	6	8	....	3	3	1	1	1	....	....	....	4	3	....	2	1	....	....	1	4	....
50-45	44	61	38	37	43	37	41	49	46	53	53	51	50	46	45	53	44	45	33	30	29	45	45	41	42	45	36	38	32	35	39
45-40	26	20	20	24	20	16	23	30	24	22	25	14	19	21	22	23	24	25	28	29	29	26	26	22	34	25	28	20	33	34	32
40-35	12	12	10	11	3	9	11	6	8	7	8	19	7	9	8	7	10	11	17	10	8	12	13	11	18	7	16	18	19	21	18
35-30	6	6	8	10	8	6	11	7	6	6	7	7	10	5	6	6	8	13	13	8	7	2	12	8	11	9	6	7	5	9	8
30-25	1	1	2	1	3	2	1	1	5	3	2	2	5	....	1	1	7	2	4	1	4	4	2	4	4	....	5	1	1	1	1
25-20	....	....	....	2	3	2	....	....	1	1	1	1	2	....	....	1	....	2	4	....	....	3	....	....	....	....	2	....	....	....	....
20-15	....	....	....	1	2	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Total	**92**	**103**	**79**	**89**	**85**	**75**	**94**	**100**	**97**	**95**	**102**	**102**	**93**	**84**	**85**	**92**	**94**	**99**	**99**	**78**	**77**	**96**	**101**	**86**	**111**	**87**	**93**	**93**	**91**	**104**	**98**

Now the advantage of taking into consideration the seasonal variation of the occurrence of lows is to change somewhat the discussion of the differences that may be observed between the data of individual years, such, for example, as the years of maximum and the years of minimum of sun spots.

Figure 6 gives the curves of mean distribution of frequency along the one hundredth meridian for the months of July, December, and April, which may be considered as representing the typical seasonal changes. The curve

[3] The Weather Bureau meteorologists are of the opinion that the personal equation of the meteorologist who draws the daily weather map does not constitute a very important factor influencing the face of the map. It is recognized, however, that personal factor is quite important when it comes to selecting highs and lows for tracing their paths during each month and also in the actual tracking of each.

As all students of our maps are more or less directly interested in this matter, the following list gives the approximate terms of service of different officials (designated by letters) in connection with the plotting of highs and lows on Charts II and III, respectively:

A, 1898–1901.
B, June, 1901–January, 1904.
C, February and March, 1904.
D, April, 1904–January, 1905.
E, February–December, 1905.
F, 1906–1910: March, 1914—date.
G, 1910–February, 1914.

Y, obtained from annual data, expresses the superposition of these three types of curves. The first maximum, *a*, affects the months June to February; the second maximum, *b*, the months of February or even January to May. If, therefore, during a given year the spring was particularly stormy, in all probability the frequency distribution of lows for the year will belong to the April type (IV). If, on the contrary, lows occurred predominantly during the summer and the autumn, the northern maximum will be more accentuated and the second maximum will be missing; the curve will belong to the July type (VII).

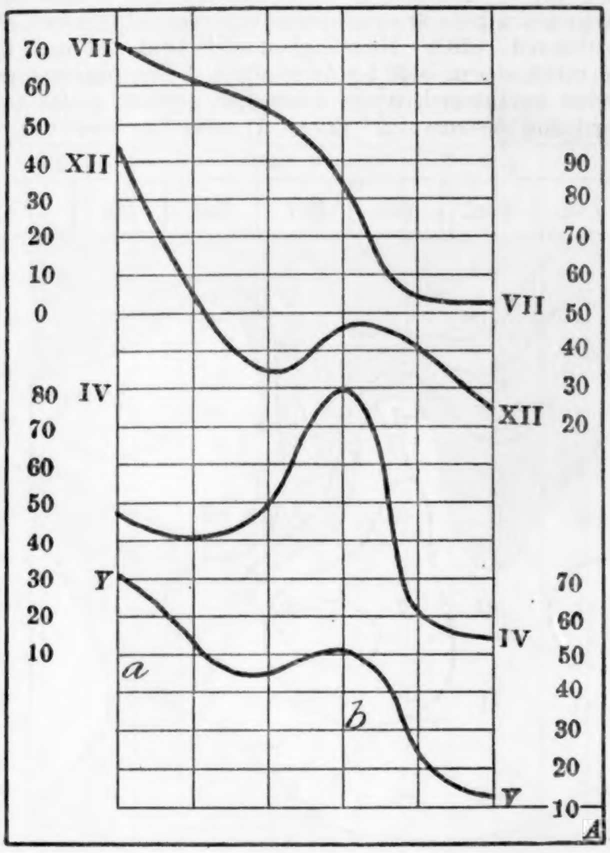

Fig. 6.—Curves expressing the mean distribution of frequency of lows along the 100th meridian in July (VII), December (XII), April (IV), and the Year (Y).

Let us see now if really important differences of the curves of yearly data are principally due to the season during which most of the lows occurred. Figure 7 presents the curves of storm distribution for those years having sunspot maxima and minima. We notice at once a radical difference, at least between the curves of 1893 and 1906 and those of 1901 and 1913. The two last-named curves are very peculiar, indeed; the curve for 1913 in particular, indicates apparently an unmistakable shifting of the northern storm-belt toward the south.

Tracing the curves for each year we notice that it is not accidental that the curves of the years of sunspot minima differ from the curves of the years of sunspot maxima; the curves for years before and after those of sunspot maxima or minima display a striking tendency to similarity. Table 3 enables one to thus trace the curves for the individual years and we need not enter into the details. Now, since the curves of the years 1883–1885, 1892–1894, 1905–1907, may be considered as being similar and as representing the conditions at the sunspot maxima[4] for three consecutive cycles, while the curves of the sunspot minima years 1888–1890, 1900–1902, 1911–1913, are also mutually similar but different from the other curves, the differences that exist between the averages of these two groups of years may serve to test the conclusion advanced by Kullmer and presented in form of a theory by Huntington.

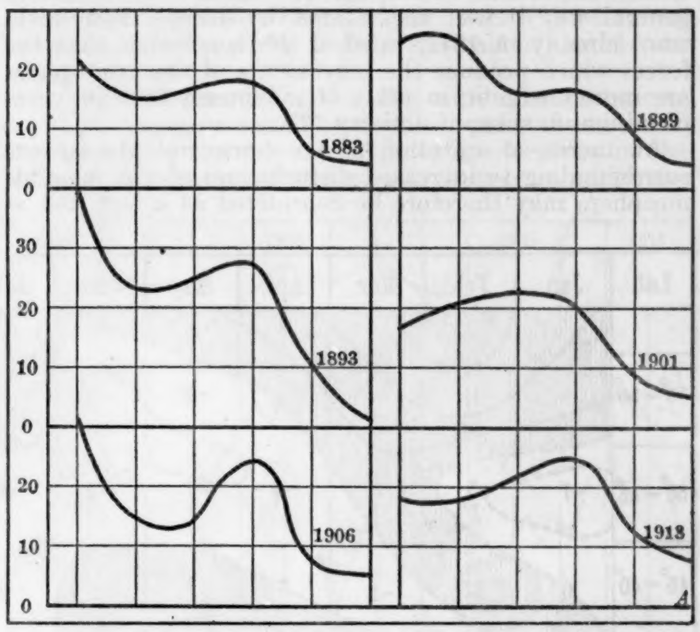

Fig. 7.—Curves of mean distribution of frequency of lows along the 100th meridian during years of sunspot maxima (1883, 1893, 1906) and sunspot minima (1889, 1901, 1913).

The monthly totals of observed lows are given in Table 4.

Table 4.—*Frequency of lows on the 100th meridian during the years of sunspot maxima and sunspot minima.*

YEARS OF SUNSPOT MAXIMA.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1883	10	5	6	7	7	5	9	3	6	4	6	13	.....
1884	10	8	7	6	8	2	5	7	11	10	6	2	.....
1885	7	5	7	6	6	4	7	4	6	5	4	7	.....
1892	10	8	9	6	11	7	12	7	10	10	12	9	.....
1893	14	9	12	9	10	11	8	6	9	15	12	12	.....
1894	11	11	13	10	4	9	6	10	13	11	14	11	.....
1905	7	10	9	15	10	7	8	7	8	9	14	11	.....
1906	11	10	10	7	14	4	4	7	6	7	6	10	.....
1907	9	6	14	11	9	8	9	8	7	7	10	8	.....
Total	**89**	**72**	**87**	**77**	**79**	**57**	**68**	**59**	**76**	**78**	**84**	**83**	**909**

YEARS OF SUNSPOT MINIMA.

Years.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1888	5	5	7	9	8	8	3	5	4	12	4	6	.....
1889	6	8	6	8	7	7	15	5	8	10	5	12	.....
1890	8	12	9	8	13	6	7	9	6	8	10	12	.....
1900	11	12	11	7	6	8	11	7	7	10	9	13	.....
1901	17	10	9	6	5	7	4	3	5	10	12	7	.....
1902	7	4	8	8	4	7	6	7	9	5	8	8	.....
1911	8	8	10	6	7	7	5	10	8	8	9	6	.....
1912	10	7	9	7	7	7	9	8	4	9	5	10	.....
1913	13	8	10	8	7	8	9	7	5	10	10	7	.....
Total	**85**	**74**	**79**	**67**	**64**	**65**	**69**	**61**	**56**	**82**	**72**	**81**	**855**
Difference	*−4*	*+2*	*−8*	*−10*	*−15*	*+8*	*+1*	*+2*	*−20*	*+4*	*−12*	*−2*	*−54*

[4] For years of sunspot maxima and minima, according to Wolf-Wolfer relative numbers, see this Review, July, 1915, p. 313.

We may first consider the difference between the annual totals. This difference is 54, or 6 storms less per year during the years of sunspot minima than during the years of sunspot maxima. This is in complete accord with one of Kullmer's conclusions, viz, that years of greatest frequency of sunspots are more stormy than those corresponding to minima of the solar cycle. The same fact was stated long ago by Poëy (24), Meldrum (25), and Piddington (26) concerning the cyclones of the West Indies, the Indian Ocean, and the China Sea; in a more general way it was also stated by Joseph Baxendell, who, already in 1871, reached the conclusion that the forces which produce the movements of the atmosphere are more energetic in years of maximum than in years of minimum sunspot activity (27).

An increased agitation of the terrestrial atmosphere corresponding to increased disturbances of the solar atmosphere may therefore be considered as a fact just as

LATITUDE DISTRIBUTION OF LOWS FOR THE DIFFERENT MONTHS DURING YEARS OF SUNSPOT MAXIMA AND SUNSPOT MINIMA.

Tables of the monthly numbers of lows observed in different latitudes during the 9 sunspot-maxima years and during the 9 sunspot-minima years, when subtracted from one another give the diagram shown in figure 8. This diagram shows that, along the 100th meridian, the annual variation of the distribution of lows in latitude is very different during the years of sunspot maxima from that of the years of sunspot minima. As far as annual data are concerned, it confirms Kullmer's conclusion: "When sunspots are numerous the main storm belt shifts northward" (28). Huntington adds that "at such times the main storm belt tends to split. The major portion moves northward, while a smaller portion shifts southward and oceanward" (29). It may be, however, that

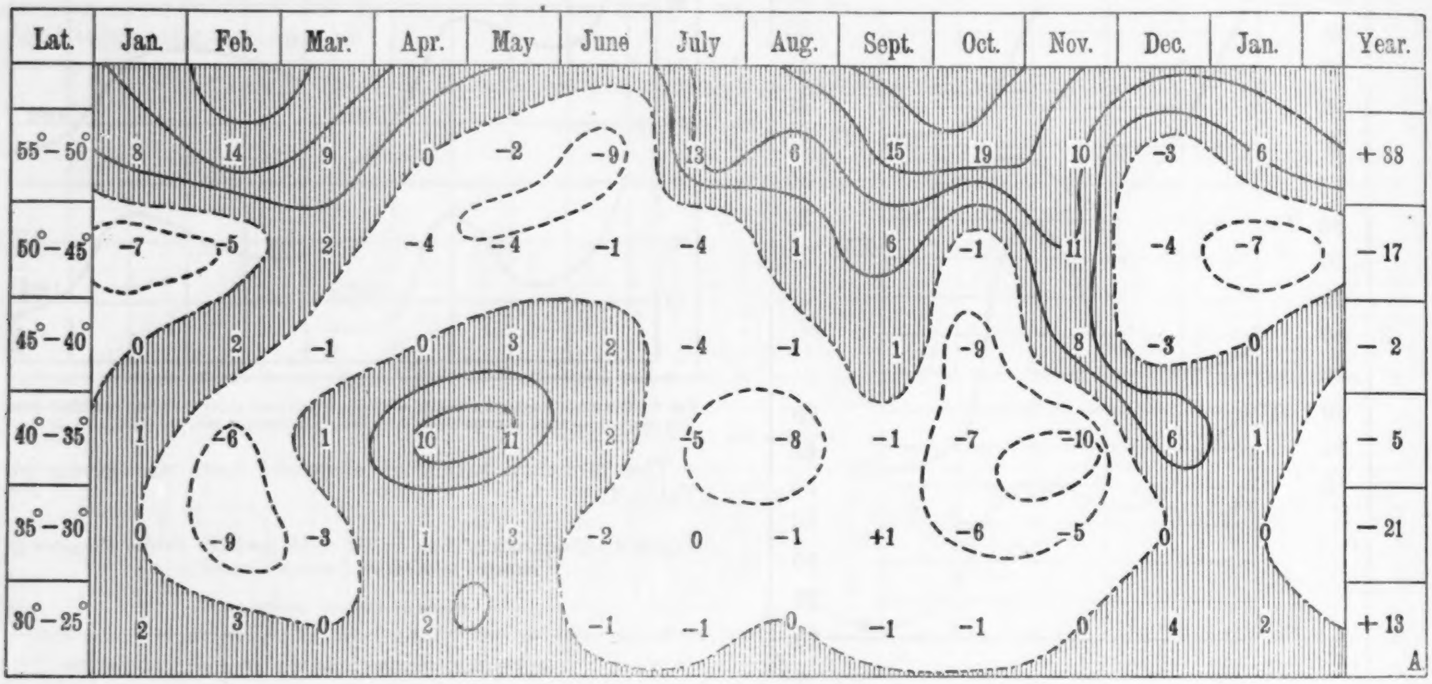

FIG. 8.—Contrast in latitude distribution of the frequency of lows crossing the 100th meridian during sunspot maxima and minima. Shaded areas indicate seasons and regions when the frequencies under sunspot maxima *exceed* those under sunspot minima.

well established as the atmospheric temperature correlation. In the case of temperature, however, the increase during the years of a sunspot minimum is very small and the correlation that exists is a most complicated phenomenon. The same may be said about storminess. First, the average of the 18 years gives only 6 lows more per year, and, since the yearly mean of the number of storms that crossed the 100th meridian is 98, it means only an increase of 6.1 per cent.

Again, if we look over the differences for the individual months we notice at once that, together with the decrease or increase of storminess, a radical difference of the annual variation appears to be a very much more important characteristic than the variation of storminess.

The decrease of frequency of lows specially affects the months March to May, September and November, whereas from June to August we notice an increase, as well as in February and October.

this displacement is only an apparent one. Bowie and Weightman show indeed very clearly that different types of lows are distinguishable and that there is a pronounced annual variation in the geographical distribution of the occurrence of these types. Concerning the 100th meridian, the numbers indicate that years of sunspot minima are characterized by a more uniform latitude distribution throughout the year. During years of sunspot maxima, on the contrary, the latitude distribution is more unequal; and in these years both belts of lows are more accentuated, the northern belt during February, September, October, and particularly in November, and the southern belt during the months of February to May. The shifting of the storm belts in accordance with the changes shown by Wolfer's sunspot numbers is therefore questionable. The action of the increase of sunspots upon the storms seems to be primarily an action of coordination. Not only the annual frequency of storms

is slightly increased, but also the paths that the storms follow are more definite and closely confined to the storm belts, in the southern belt from March to June, in the northern during the rest of the year.

The conclusion to be drawn from this coincidence is that the annual variation in the geographical distribution of atmospheric pressure must be essentially different in the years of sunspot maxima from that during years of sunspot minima. It seems probable that the gradients must be more pronounced or less pronounced in harmony with the coordination or lack of coordination of the tracks of barometric lows.

THE PLEIONIAN VARIATION OF THE FREQUENCY OF LOWS.

On the following diagram (fig. 9) the curves *A*, *B*, and *C* express graphically the overlapping totals of yearly frequencies of lows crossing the 100th, the 90th, and the 80th meridians, curve *S* gives the annual values of the relative numbers of sun spots and curve *E* represents the variation in frequency of lows observed on the 80th meridian between 45° and 40° of latitude. This last curve will simply serve for the purpose of demonstrating a striking disagreement with the sun-spot curve as well as some very pronounced disagreements with the curve giving the total number of lows for all parallels along the 80th meridian.

The disagreements between curves *C* and *E* show most plainly how important the shift of the main storm belt may be occasionally. I shall insist upon this fact later. Comparing the curves *A*, *B*, and *C* with *S*, we notice at once that the variations in frequency of storms correspond but vaguely with the sun-spot variation. Some degree of correlation is undeniable, but this correlation is certainly not the main factor affecting the variation of frequency of lows. We must admit that the maxima of frequency of sun spots show corresponding maxima of frequency of lows; but at sun-spot minima we observe also maxima of lows. Therefore the period of the variation of atmospheric storms—as far as the United States are concerned—must be at least one-half of the 11-year cycle.

In order to harmonize this fact with solar variations, we might imagine that the double period of terrestrial storminess corresponds to the known variations in the latitude distribution of the solar prominences, which are concentrated in two zones at both the times of maxima and of minima of sun spots, but lie in four zones during the intervening years (**30**). Again, one might imagine that this terrestrial double period is related to the secondary maximum of sun-spot frequency recognized by De la Rue and others (**31**). The curves of overlapping totals of lows display, however, secondary maxima between the so-far admitted maxima. If therefore we accept as real the correspondence between the solar curve and the frequency curves of storms, we must admit that upon the 11-year period is superposed a shorter period of about $2\frac{3}{4}$ years' duration and that this period is predominant

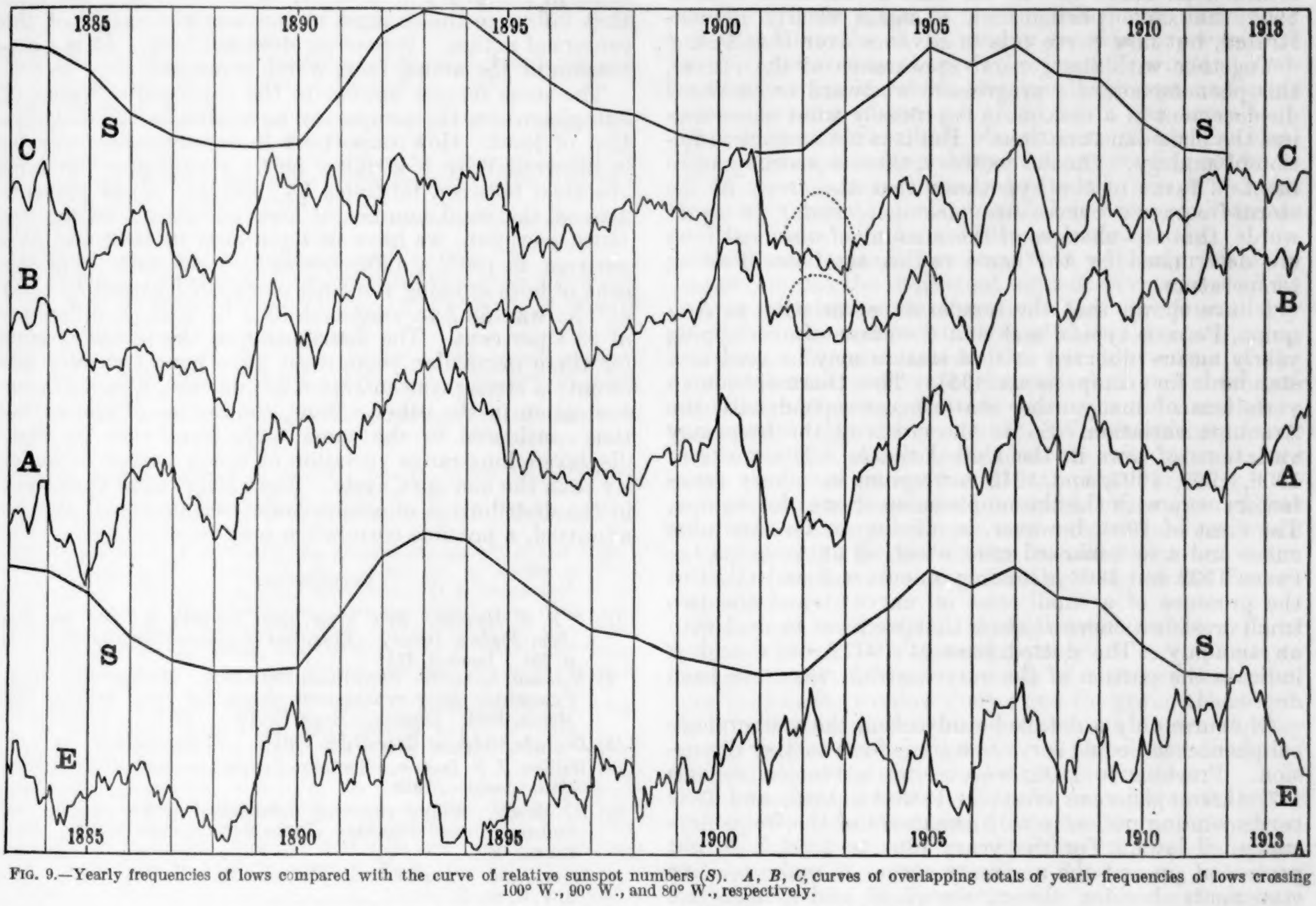

FIG. 9.—Yearly frequencies of lows compared with the curve of relative sunspot numbers (*S*). *A*, *B*, *C*, curves of overlapping totals of yearly frequencies of lows crossing 100° W., 90° W., and 80° W., respectively.

E, the yearly frequency of lows crossing 80° W. between 45° N. and 40° N.

in its effects upon atmospheric phenomena. A solar period of 1,004 days (or 2.75 years) has already been found by Bigelow (**32**), and the above inference from the inspection of curves *A*, *B*, and *C* of figure 9 harmonizes very well with Bigelow's short period (**33**).

However, it may be that the mean duration of this most characteristic variation is shorter than 2.7 years. In studying the consecutive means of atmospheric pressure, temperature, and sunshine for New York City I have found a mean of 25 months (**34**). A similar result was also obtained long ago by H. H. Clayton (**35**). Moreover, it is only as a first approximation that we may admit a correspondence of the maxima of curves *A*, *B*, and *C* with the principal maxima and minima of the sun-spot variation. In reality the phenomenon is more complicated. We notice indeed that the maximum of 1900 on curve *A* is retarded on curve *B* and very much more retarded on curve *C*. In the case of the maximum of 1905 the same phenomenon is again clearly demonstrated, but now curve *C* is in advance over *B* and *A*.

Together with the general appearance of the curves, this phenomenon of a progressive westward or eastward displacement of a maximum is precisely what characterizes the pleionian variations. But it is not a simple question of analogy. On the contrary, there is a strong argument in favor of the hypothesis that the crests of the storm-frequency curves are pleionian crests; in other words, that the changes of the amount of observed lows are determined by the same causes as those affecting temperature.

I have shown that the temperature variation at Arequipa, Peru, is typical and that the curve of overlapping yearly means observed at that station may be used as a standard for comparisons (**36**). The thermopleionian variations of many other stations correspond with the Arequipa variation. So do the crests of the frequency variations of lows in the United States. The crests of 1900, 1905, 1907, and 1912 correspond in a very satisfactory way with the thermopleionian crests of Arequipa. The crest of 1909, however, is missing on the Arequipa curve and a well-marked crest observed at Arequipa between 1902 and 1903 is missing on curves *B* and *C*. But the presence of a small crest on curve *A* and the two small crests on curve *B* show that we have to deal with an anomaly. The dotted lines at 1902.5 on *C* and *B* indicate the portion of the curves which may have been depressed.

Of course only a detailed study of all the meteorological phenomena could serve as a basis for a further discussion. Previous to 1900, we observe in tropical regions (**37**) thermopleionian crests in 1883-84, 1886, and 1889 corresponding perfectly with the crests of the frequency-curves of lows. For the years 1891 to 1899 I do not possess at present the necessary curves to make positive statements; besides, the curves *A*, *B*, and *C* disagree. The number of very satisfactory correspondences that have been noticed is sufficient, however, to draw the conclusion that the frequency-variation of barometric lows in the United States is related to the pleionian variation.

If this conclusion is correct—and remembering the important yearly variation of the distribution in latitude of the lows which must be due to the seasonal differences in the distribution of atmospheric pressure—we must admit that in a similar way the presence of a baropleion on one part of the continent will influence the average movement of the lows. It may be that the lows have a tendency to swing around the area of abnormally high pressure; if so, the shifting of the storm belt from year to year must be due to passing or pendulating baropleions.

Evidently a great amount of research work remains to be done in order to verify this hypothesis. First of all, the normal conditions of the circulation of lows are far from being well known. Four most important "centers of action" influence directly the atmospheric disturbances observed in North America. During the summer the North Pacific and the Icelandic centers of action practically join into one low pressure belt; the high-pressure areas of the Atlantic and Pacific Oceans are generally more or less connected from October to March, at least so far as average conditions are concerned. It seems to me that in the present state of our knowledge it would be difficult to decide whether it is variations at these centers of action that determine the observed pleionian variations in frequency of lows or, on the contrary, the lows that influence the changes in position and extent of the centers of action. Reasoning does not help. It is a discussion of the actual facts which is needed.

The same remark applies to the supposed influence of baropleions on the temporary anomalies in the distribution of lows. How important these anomalies may be is illustrated by a striking fact. Expressing the lows observed between latitudes 55° and 45° N. as percentages of the total number of lows observed crossing the 100th meridian, we have 63.1 per cent in 1896 and 34.5 per cent in 1902, a difference of 28.6 per cent. The per cent of lows crossing the 80th meridian between 50° and 45° N. was 58.7 in 1898 and 33.3 in 1901, a difference of 23.4 per cent. The distribution of the tracks of lows for these particular years must have been radically different; a strong concentration in one case, a lack of concentration in the other. Now, the degree of concentration considered in the same way, from year to year, displays a long-range variation of much longer periodicity than the sun-spot cycle. Since long-range variations in the distribution of atmospheric pressure must also be admitted, a possible correlation may be expected.

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(33) In his paper: "Studies on the general circulation of the earth's atmosphere." (Amer. J. Sc., 1910. ser. 4, v. **29**, p. 277.) *F. H. Bigelow* makes the statement: "It is found that in the analysis of the sunspot numbers the prominence frequencies and the magnetic field intensities, there is usually superposed upon the long period, ranging from 8 to 14 years, four minor crests, though only three of them are fully developed in some periods."
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A UNIFORM THERMOMETER EXPOSURE AT METEOROLOGICAL STATIONS FOR DETERMINING AIR TEMPERATURE AND ATMOSPHERIC HUMIDITY.

By Vladimir Köppen.

[Sections translated from Met. Ztschr., 1913, **30:** 485–488, 513–523.]

* * * All in all, we are at last in a position to state definitely the errors due to the customary thermometer exposures, to attack the problem of eliminating these errors, and to begin to work toward a uniform manner of exposing thermometers throughout the world. Although it is much to be regretted that we still have no such series of comparisons in tropical and subtropical regions as are available for central and northern Europe, nevertheless the already observed differences due to sun's altitude, cloudiness, and wind velocity enable us to draw quite approximate conclusions for the Tropics also.

The daily means of temperature, so far almost the sole element employed for making climatological comparisons, do not vary greatly even for quite divergent methods of exposure because their daytime and nighttime errors balance each other to a certain extent. The latter is least true for great massive shelters such as those of Wild and Neumayer, because in these the daily heating in the sunshine and the nocturnal damping due to the mass of wood upset the balance so that their records yield too high daily means. On the other side stands the English shelter, which, according to the Potsdam comparisons,[1] gives a prevailing too low daily mean. For the 24-hour means in the English shelter during the long-night months of November to February were 0.2° to 0.3°C. lower than those in the [metallic window] shelter, while from March to October both exposures gave means agreeing within ±0.1°C. Again the mean temperature from thrice daily observations within the English shelter departs from that of the surrounding air determined in the same manner by more than 0.1°C. (at Pavlovsk this holds for June and July only; at Potsdam for these same months and also in January only).

We must demand, however, that not only the daily means but also the individual term-observations shall be comparable, and this also both for our prevailingly cloudy climate and for climates of clear skies and strong radiation. In other words, the monthly means of the term-observations in such climates shall not show systematic errors, i. e., influences due to thermometer exposure, greater than 0.1° or 0.2° C. We must demand that the important climatic element of daily temperature range shall be susceptible of comparative study. At present, even under selected favorable exposures in Potsdam, this element is 20 per cent greater in June when measured in the English shelter than if determined in the Prussian window shelter and still greater if the French exposure is used.

Hellmann is right in the closing sentence of his report[2] when he says, "It is quite inappropriate to employ two fundamentally different methods of thermometer exposure, such as the window shelter and the ground shelter, in one and the same meteorological réseau, for we thereby greatly reduce the comparability of the observations and particularly of the individual term observations."

This statement, however, is to be extended to the whole globe. We must endeavor to establish a network of comparable observations embracing the whole globe, and must not be content with a Prussian, a French, a German-Colonial, and various other concepts of air temperatures. Naturally, it will require many years to actually attain this ideal; therefore the sooner we begin to strive toward it the better for all.

It will be impossible to adopt a window exposure, or any other such location in the shadow of a building, for our universal uniform exposure. To be sure, such an exposure most readily avoids disturbances due to radiation, and in our climate it yields quite good comparable means. But there are to be considered—

(1) The air in such a shadow is an exception, while the air over an open surface is the rule; hence the former may

[1] Hellmann *in* Bericht, Preuss. Meteorol. Instit., 1911, pp. 64–68.
[2] Hellmann *in* Bericht, Preuss. meteorol. Instit., 1911, p. 83.

not be regarded as the true representative of the local climate.

Of the two climates possessed by every locality the principal climate is its climate in the sun and not its climate in the shade—the "climate in the sun" meaning the actual properties of the air over open fields and not, of course, the indications of a thermometer openly exposed in the sun.

(2) The heights of the houses, the orientation of the wall, the relative locations of neighboring buildings are rarely all exactly the same for two different window exposures. The various measures adopted under these circumstances for the purpose of screening the thermometer from the sun at certain hours of the day are rarely effective. Screens can indeed protect the thermometer against the sun's rays, but can not prevent the adjacent wall and its contiguous air from heating up. If the thermometer is exposed in an angle then the ventilation is too greatly checked.

We must therefore resort to shelters standing in the open. The slighter departures of thermometers in the English shelter from the true air temperature teach us:

(a) That there is an actual urgent necessity for the extensive exclusion of the reflected radiation by means of the double louvers; that is, to expose the instruments in darkness as contrasted with the bright, "open screening" of the French and the Glaisher stands.

(b) That the thermometers depart more from the true air temperatures when exposed in large, massive shelters, such as those of Wild and of Neumayer which obstruct the wind movement, than they do in small shelters. The departure is due on the one hand to the stronger warming by the sun and on the other to greater lag behind the changes in the air temperature.

The departures from the true air temperatures, as still shown in the English shelter, are indeed smaller than those found in the other styles of exposure, but they are similar in direction, viz, too great influence of radiation and too small air movement during calms.

CONDITIONS NECESSARY FOR DETERMINING AIR TEMPERATURE.

Before turning to the discussion of methods for eliminating these errors, we may give brief consideration to the conditions necessary in determining the true temperature of the air.

(1) The screening must, in addition to protecting against rain and injury, ward off radiation without causing the thermometer reading itself to depart from the temperature of the air to be measured.

(2) The longer the time during which the air is in contact with an irradiated surface or a radiating surface, or the longer the path across such surfaces followed by the wind, the less able is the air to bring such a surface to the original air temperature.

(3) The greater the storage capacity of any object for heat, the slower and smaller its changes in temperature as compared with those of the air in contact with it.

These considerations may be applied to our problems as follows:

By reason of (1) it is desirable that the temperature of the inner surfaces of the screen and shelter shall depart very little from the temperature of the air, and the same holds for the exterior surfaces so far as they may be able to affect the temperature of the air that bathes the thermometers. For this reason we must (a) devise a screen having very slight absorption and radiation and *keep it in that condition;* (b) introduce a thermally bad conductor between the inner and the outer surfaces of the screen; best of all would be to introduce a mass of air at the desired temperature. Both these objectives are excellently attained in the Assmann aspiration-psychrometer.

By reason of (2) it is necessary that both the thermometer and the screening shelters [3] be as small as possible along the direction of the air current, and the velocity of that current must be so large that the air remains a very short time in contact with the shelter. As the horizontal component of the air movement about and within the shelter is certainly much greater than the vertical, we are chiefly concerned with the former.

Condition (3) requires that all parts whose temperature can influence that of the air or of the thermometers, shall have the smallest possible mass and thermal capacity; and that reservoirs of stagnant air shall be eliminated. It must be borne in mind, however, that transitory changes in temperature affect but a shallow superficial layer of a poor thermal conductor, while the whole mass of a metal object will be warmed through or cooled off; thus the thermal capacity of wooden parts is smaller, in general, than that of metallic parts.

The above conditions are quite well fulfilled by the small 1883 model of the English shelter. It probably affords adequate protection against reflected radiation and weak insolation. The radiation from a high standing sun, however, and the nocturnal radiation against a clear sky both falsify its internal temperature readings to an extent that far exceeds the permissible limits for climatological investigations.

There was a very early demand for a screen to protect the English shelter against these radiations. Thus Gaster, during the discussion over the new English shelter before the London Meteorological Society on November 21, 1883, stated that when he spread a large sunshade over a Stevenson shelter he found the inside forenoon temperature to stand 1.4°C. lower than that within a neighboring unscreened shelter. On the same occasion, Dr. Marcet reported that in Cannes it had been necessary to set up the Stevenson shelter in the shadow of a house in order to eliminate the strikingly excessive maximum, and that one of his compatriots there had built a shed over it. Dr. Marcet thought that if such a "sheltered screen" were found necessary in southern France the same foresight must also be needed in England. Stow [4] thought that appropriate modifications would adapt the Stevenson shelter to all climates, although it might perhaps be desirable to provide a triple roof with felt or straw in the middle for tropical stations. I have already mentioned the shading of the louvered screens in the Tropics (Samoa, Tonga).

Among all meteorological elements it is the temperature and the moisture of the air whose determination is subject to the same conditions and partially measured with the same instruments. We measure air pressure indoors, the wind at the highest, almost inaccessible points of our buildings, the rain as near as possible to the ground and in wind-sheltered localities but naturally not in the rain-shadow or under the eaves. For the observation of atmospheric temperature and moisture, on the contrary, our object is to secure uniform measurements of these properties, which we have selected for geographical comparisons, by exposing the instruments to the greatest possible mass of air and screening them as perfectly as possible from all other influences. Furthermore, these conditions must be fulfilled as perfectly as possible not

[3] The measurements by Knoch and by Barkow, quoted in foot note 5 show that the greater portion of the air current never enters the shelter but merely flows round it.
[4] See Archive d. deut. Seewarte, 1887, No. 2, p. 46.

only for the observations at term-hours but also for all the intervening time, on account of the registering and recording instruments. Experience shows that Assmann's aspiration-psychrometer is the best device for securing the necessary simultaneous exclusion of radiation accompanied by adequate ventilation. An uninterrupted artificial ventilation is so costly, however, and its installation generally so troublesome that probably it is feasible at large observatories only. Aside from its high price, M. 175, the nature of the aspiration-psychrometer makes it unsuitable for the usual term-observations by an average observer. In such a case also the location of its air intake must be just as carefully selected and adhered to as in the case of a fixed thermometer exposure; the readings must accurately follow the instructions; and it would be necessary to replace the original thermometers by others somewhat less sensitive to allow of a quiet reading of both thermometers on days with the well-known rapid fluctuations, since it is desired to secure the mean temperature of the last two minutes. Determinations with the portable Assmann aspiration-psychrometer have more the character of a physical experiment—invaluable for checks on accuracy—rather than an equivalent for the systematic uniform observations of a meteorological réseau. The registering apparatus and self-recording thermometers in any case require, in addition, a fixed mounting and exposure.

Experience has shown that the box closed on all sides by double, oppositely inclined louvers, which is called the "English shelter" and which allows air to pass through but admits very little light or radiation, may be regarded as the most efficient fixed thermometer exposure for the determination of the temperature and the moisture of the air. This shelter also affords the instruments excellent protection from injury and dampness. Therefore the essentials of this screen must be retained, but we must seek to eliminate its remaining shortcomings so far as we know them. Both the shelter and the instruments it is to screen must be mutually adapted and reconstructed. When the Stevenson shelter was devised there was no thought of exposing in it clock-driven, recording instruments. Later as these recording instruments, particularly the small-model "Richards" came more and more into use they were housed in the shelter as best one could. Since they thereby interfered with particularly the maximum and minimum thermometers—which seemed indispensable—it was therefore decided to enlarge the shelter without heeding the warning example of Wild's large shelter and Aitken's experiments. The thermographs and hygrographs still thus employed are, moreover, merely planned like Richard's first effort—his barograph. Their bulky glass cases constitute reservoirs of heat and of differently tempered air, they hinder wind, and are in entire contradiction to a rational device for determining air temperature. If the wind comes from the direction of the case, then the temperatures both of the laterally attached thermograph element and of the psychrometer are falsified.

Bearing this in mind, and also the interrelation of air temperature and moisture, I have had Mr. C. Schneider build a thermohygrograph based upon our experience with the kite meteorograph. The thermohygrograph, in spite of its open scale ($1° = 2$ mm., 1 per cent $= 0.5$ mm.) weighs but 1.4 kg., the thermometric element is freely exposed in all directions and is separated by the aluminum base-plate from the drum which alone is inclosed in a case. Its dimensions are: 32 cm. wide, 14.5 cm. deep, and 31.5 cm. high. (See fig. 4.)

For the installation of this thermohygrograph and psychrometer I have modified the small-model "English screen" of the Prussian Meteorological Institute. (1) The depth of the screen is diminished about 10 cm.—i. e., from 29 to 19 cm. inside measure; (2) in its left or western side, for a length of 35 cm. the floor and the three lower louvers are removed and a new similar floor inserted 13 cm. higher, thus making a step, part of whose tread swings round for convenience in placing and adjusting the thermohygrograph. The lowest louvers of the left side were shifted to the right margin of the cut-out portion, thus making a louvered box $14 \times 19 \times 10$ cm. inside measurement, into which project the bulbs of the thermometers 11 cm. below the base plate of the thermohygrograph; (3) the ventilation of the lower and essential part of the shelter was improved by beveling the frame parallel with the louvers above it, thus making an opening similar to the others. The upper part of the shelter may, on the other hand, be simplified, since its purpose is merely protection from the rain and mechanical injury.

The number of stations equipped with registering apparatus—first-order stations of the Vienna Meteorological Congress—is growing rapidly. It is not to be expected that all the second-order stations equipped with a psychrometer and barometer but not a registering apparatus, should be converted into first-order stations; both the cost of apparatus and the impossibility of discussing such a mass of records prevent this.

However, it is notorious that the English shelter gives, even in middle and northern Europe, with clear sky and weak wind, temperature readings 1°C. too high in the afternoon and about ½°C. or more too low at night. These errors must be even greater in lower latitudes and with stronger radiation. Since in climatology we work with differences of the tenth part of a degree, we should not be satisfied with such service after having discovered these facts, but must endeavor to remove these errors.

This may be attained in two ways. A smaller shelter will diminish the errors, but to obviate them one must either screen the shelter from strong radiation or introduce an artificial ventilation of the instruments. By "strong radiation" in this connection is meant the direct insolation from the sun standing high in the heavens and the radiation to the zenith. The English shelter can be regarded as a sufficient protection against approximately horizontal rays and terrestrial radiation. The wind need not and should not be hindered of free access to the principal under part of the shelter.

Since the obstruction of the wind is one of the greater evils and since we can better afford, under extreme conditions, a few errors in radiation, we may adopt solar altitudes of 20° or higher as those against which we need additional protection. We thereby secure the great advantage that we can freely expose the entire lower half of the shelter to the wind. If only a point were to be thus screened, then such solar altitudes would require a cylindrical screen having its axis parallel with the earth's axis; the upper or poleward edge would be cut at right angles to the axis, but the bottom would be cut off horizontally. Since the entire lower half of the screen, together with the sensitive parts of the thermometer and of the thermograph, require protection from the sun's rays, the shape of the screen is more complicated and its development becomes more difficult in order to avoid an unnecessarily large screen.

The ingeniously designed nomographic tables of my colleague, Prof. Stück, have stood me in very good stead here, aiding in determining the azimuths of the sun when

at altitudes of 20° at the solstices in every geographical latitude. Since these meteorologically important shadow conditions are nowhere available in a lucid and convenient arrangement, the most important particulars may find room in the following table, for which I am indebted to Prof. Stück. The time is true time; refraction is neglected. The azimuths are given for both the sun's altitude and the hour of the day. As the table shows, if the evening observation is taken at 9 p. m., it will always be after sunset for localities up to latitude 60°, and if taken at 8 p. m. for localities up to 48°.

TABLE 1.—*The sun's positions.*

Lat. N.	Time of—		Azimuth (a. m. = east; p. m. = west).				Sun's altitude.		
	Sunrise.	Sunset.	$h=0°$.	$h=20°$.	7 a. m.	8 a. m.	7 a. m.	8 a. m.	Noon.
I. June 22 (equation of time +1½*min*).									
°	A. M.	P. M.	° *N.*	° *N.*	° *N.*	° *N.*	°	°	°
0	6.0	6.0	66.5	64.9	65.8	63.4	13.7	27.3	66.5
10	5.7	6.3	66.1	68.5	68.4	68.5	17.6	31.4	76.5
20	5.4	6.6	64.9	71.4	71.7	74.7	21.1	34.6	86.5
30	5.0	7.0	62.6	73.7	75.6	81.7	23.9	36.6	83.5
40	4.6	7.4	58.6	75.6	80.2	89.2	26.0	37.4	73.5
50	3.9	8.1	51.7	76.9	85.2	96.8	27.3	36.9	63.5
60	2.7	9.3	37.1	77.4	90.4	104.0	27.6	35.1	53.5
70	....	....	....	76.1	95.6	110.4	27.1	32.1	43.5
80	....	....	....	67.7	100.5	115.7	25.7	28.2	33.5
II. December 22 (equation of time −2*min.*).									
			° *S.*	° *S.*	° *S.*	° *S.*			
0	6.0	6.0	66.5	64.9	65.8	63.4	13.7	27.3	66.5
10	6.3	5.7	66.1	60.3	63.9	59.3	9.5	22.5	56.5
20	6.6	5.4	64.9	54.3	62.8	56.2	5.0	17.1	46.5
30	7.0	5.0	62.6	45.6	62.4	54.1	0.4	11.4	36.5
40	7.4	4.6	58.6	30.8	....	52.9	....	5.4	26.5
50	8.1	3.9	51.6	....	....	52.6	....	....	16.5
60	9.3	2.7	37.1	....	....	....	....	....	6.5

The fact that the extreme northerly or southerly azimuth for a solar altitude of 20° at the summer solstice is almost the same between latitudes 40° and 70°, differing but a few degrees even down to latitude 20°, greatly simplifies the problem of constructing the shading screen. In order to simplify the future construction of this screen I needed to design but three forms of the same, adapted respectively to use in latitudes 0°–10°, 10°–25° and higher than 25°. For practical purposes the poleward corners (wings) are clipped off vertically instead of along an element of the cylinder. The description of the screen will be given farther on. In constructing the screen, I choose such soft roofing material as may be locally available, such as straw, reed, palm leaves, grass, or foliage, just as is done for the Indian thermometer shelter. Such roofing when 10 to 20 cm. thick, has the advantage that insolation and nocturnal radiation do not penetrate to its under surface, as the constituent straw or leaves of this surface are freely bathed by the air, their temperature is not seriously different from that of the air itself. For the uppermost roofing of the shelter, I employ a soft roofing of the same kind, a 5 to 10 cm. layer of the same material instead of the wooden board of the English screen. This roofing and partly the screen itself so far weaken radiation to the sky that the louvered shelter itself cuts out what remains.

The proposed universal thermometer exposure is thus in a certain sense a combination of the two methods at present most widely used, reduced to the smallest practicable scale and executed in a more appropriate manner.

VENTILATION.

The question of ventilation remains to be examined. The effect of air motion on the thermometer in a shelter is two-fold. On the one hand, the wind sweeping past and through keeps the shelter itself at a temperature which more nearly approaches the temperature of the air, the stronger the wind, the smaller the shelter, and the weaker the radiation to which the shelter is exposed. Just as the shelter, or at least parts of it, often remain at a temperature not inconsiderably different from that of the air, so in similar manner the thermometer in its turn experiences through the radiation of the shelter walls, heat or cold which needs to be removed by air flowing past. According to observations in Potsdam, the horizontal air motion in an English shelter amounts to about one-seventh (14.3 per cent) of the wind velocity close above the screen.[5] It is obvious from this that even at an average wind velocity of 4 to 5 m/sec., the air motion at the thermometer sinks under 0.7 m/sec. and can be sufficient only when the temperature of the shelter walls differs but little from the temperature of the air. If the shelter is shaded and small the latter condition is secured; but should the wind velocity outside of the shelter fall to under 1 m/sec. while the radiation from the ground, etc., is strong, then even these measures will not avail. Under such conditions only artificial ventilation by means of an aspirator will give us error-free temperature determinations. There must be uninterrupted artificial ventilation for registers and self-recording extreme thermometers. Since most stations will find it too difficult and expensive to maintain such a permanent artificial ventilation, it will generally have to be omitted, so that it becomes all the more important to perfect the natural ventilation and the screening against radiation. Artificial ventilation at term-observations for the dry bulb (that is, exposed thermometer) also may all the more appropriately be considered here since many réseaus (e. g., the Prussian and the Deutsche Seewarte) have already employed powerful psychroaspirators to secure that approximately uniform air current past the wet-bulb thermometer which is required for the proper application of the psychrometric formula.

DETAILS OF THE THERMOMETER EXPOSURE.

We will now proceed to the description of the individual parts of the proposed thermometer exposure. These consist of:

(*a*) A uniform shade screen with its support for all stations measuring temperature.

(*b*) Larger louvered shelters for first-order stations, and smaller shelters for the second-order stations.

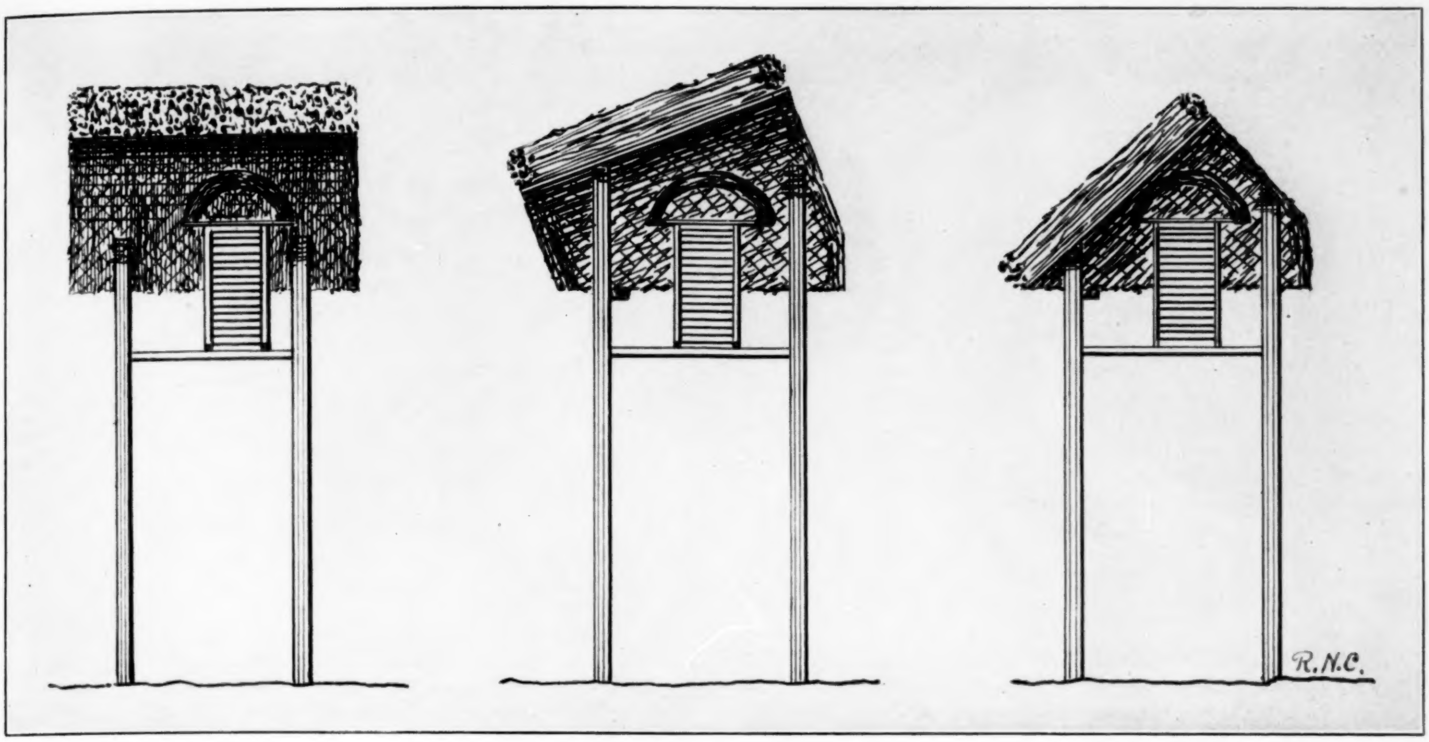
(*c*) The instruments, which are the psychrometer and thermohygrograph at stations of the first order; and psychrometer and extreme thermometers, or extreme and exposed thermohygroscope at stations of the second order.

(*d*) An aspirating device for the psychrometer.

Of these parts, the accessories (*a*), (*b*), (*d*) serve to support and protect the principal part, (*c*), so that it may indicate truly. In this cooperation the straw or other soft roofing guards the shelter from strong radiation—both solar and terrestrial—while the louvered shelter screens the instruments[6] from the weaker radiations of

[5] *Knoch* finds the relation is 16 per cent inside a shelter in the field (Abhdlg., Preus. met. Instit., **3**, p. 6); while *Barkow* finds 14 per cent inside a shelter on the tower, and varyng greatly with the wind directions (Jhrb., Preus. met. Instit., 1909, p. 99.)

[6] The straw screen alone, in common with the French shelter and the older English "open" shelter, would give much too high temperatures by day, and too low temperatures by night.



Tropical. Subtropical. Extratropical.

FIG. 1.—Köppen's "screened shelter"; side elevations of the three models.

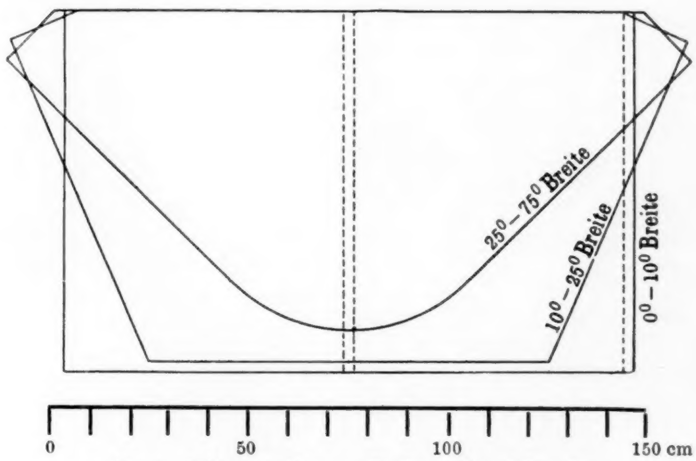


FIG. 3.—Patterns for the screens for the shelters of figure 1. (Breite=latitude.)

FIG. 2.—The extratropical screened shelter as it would appear in use.

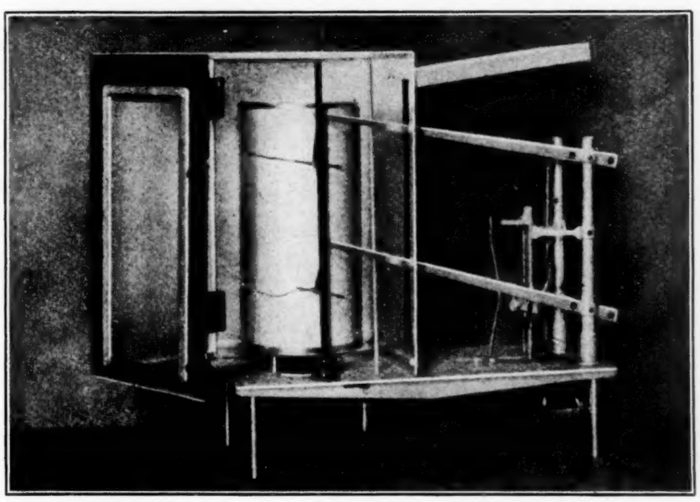


FIG. 4.—Photograph of Köppen's improved thermohygrograph, recording on rectangular coördinate paper.

the ground and other objects, from rain and from mechanical injury. Finally the aspirator has to make the wet-bulb thermometer independent of the wind and also to insure correct dry-bulb indications during calms.

A. Screen and frame.—The screen support consists of four 6-cm. posts for latitudes between 10° N. and S., as shown in figure 6. Three 8-cm. posts serve in all higher latitudes. The posts carry a frame of 4 battens at a height of 190 cm. above the ground, and this frame bears the instrument shelter. The two northern posts are on a true east-west line and 130 cm. between their outer surfaces, the third post, on the south, is 120 cm. from each of the others, again measuring between outer surfaces. The necessary braces should be of small cross section in order not to interfere with ventilation, and partly replaced by wires.

In constructing the screen a coarse-mesh wire netting of galvanized iron or steel wire is cut to that one of the patterns of figures 1 and 3 appropriate for the latitude of the station, is bound with stronger wire, and fastened to the five parallel wooden strips shown by dotted lines (fig. 3). In this condition, the net can be conveniently rolled and shipped; but since it may be easily distorted, a paper pattern of its form should accompany it. Upon reaching its destination, it is shaped and bound to flexible rods, preferably of rattan. Two crosspieces, 130 cm. long, are then fastened at front and back, giving the screen its cylindrical bend whereby its lower edge becomes horizontal. Such soft roofing as is locally available is then fastened to the netting by means of soft wire. The front crosspiece is permanent and eventually rests upon the tops of the two fronts posts [7] but the rear crosspiece is only temporary.

After the tops of the three post ends are fashioned, as shown in figure 1, the completed shade screen is placed upon them. The middle and two outer parallel sticks are firmly screwed to the post ends, adjusting the horizontal lower edge of the screen so that it is 25 cm. above the frame supporting the louvered shelter, or 215 cm. above the ground. A horizontal crosspiece is fastened to the north side of the southern post [8] and supports the edge of the screen which is firmly fastened to it. This completes the fastening of the screen.

It should be noted that in order to secure the necessary shade in the morning and evening the bottom edge of the screen must project northward beyond the outer side of the post, as follows: For the extratropical form, 10 cm.; for the equatorial form about 25 cm.; and for the intermediate form about 15 cm.

The rear [southern] edge must extend 25 to 30 cm. beyond the southern post or posts. The dimensions are those of the shade screen for the larger shelters (with registering apparatus). Although the small shelter is 15 cm. narrower and 9 cm. shallower, I recommend that the same shade screen be used for it, then if a second-order station should install a thermohygrograph, only a new shelter need be supplied.

B. The louvered shelter.—(a) This is equipped as follows for stations of the ***first order:*** The external dimensions, including the inner roof, are identical with those of the small model "English shelter" of the Prussian Meteorological Institute, except that the depth is 10 cm. less. The measurements are:

Outside: 59 cm. wide, 30 cm. deep, 53 (70) cm. high.

Inside: 48 cm. wide, 19 cm. deep, 47 cm. high.

The southward sloping board, forming the outer roof of the English shelter, is replaced by an arched straw roof, whose center rises 15 cm. above that of the inner roof.

In order to conform more closely than in the past with Aitkens's principle of restricting temperature-influencing objects to minimum dimensions, I have pushed in the lower part of the eastern louvers of the shelter 35 cm., so that the thermometer bulbs of the psychrometer are placed in a space 14 (W—E) × 19 (N—S) cm. As in the English screen, both this lower level and the upper level of the shelter floor is composed of three small boards which are so placed that as much air as possible can reach the thermograph element and the thermometer bulbs, while at the same time all radiation [9] from the ground is excluded. At the upper level, which receives the thermohygrograph, the middle board is fastened rigidly, forming the support of the revolving frame carrying the lateral boards.

(b) For ***stations of the second order*** the dimensions of the louvered shelter are:

Outside: 44 cm. wide, 21 cm. deep, and 46 (63) cm. high.

Inside: 33 cm. wide, 10 cm. deep, and 40 cm. high.

These dimensions will admit even maximum and minimum thermometers; while the width may be further reduced by 4 cm. if they be replaced by the thermohygroscope to be described later. Such small shelters need not have a step in the floor; but otherwise the construction may be identical with that of the shelters for first-order stations.

There should be an essential difference between the upper and lower parts of either sized shelter. In the English screen the temperature at noon on clear days is markedly higher in the upper than in the lower portion and therefore the departure from the true air temperature is there greater. It is, therefore, advisable (1) to shift all essential receiving instrument parts to the lower portion, (2) to construct this portion carefully with a view to securing greatest possible ventilation while protecting against radiation and the flow of air from the upper to the lower part. At the same time the air circulation between the two portions should not be so obstructed that possible overheated air in the lower portion can not easily escape to the upper part. The mode of exposure here proposed accomplishes this by placing the thermometer bulbs of the psychrometer and also the element of the thermograph in the lower portion, while the latter is also screened by the base of the apparatus. Under these conditions it does no harm if the upper part of the shelter is at times partially exposed to the sun's rays, and the five upper double louvers of the always shaded back may be replaced by single louvers. In the lower part of the shelter, on the other hand, all care has been taken to increase accessibility to the air and at the same time exclude light from the interior. In particular the much too narrow outer opening under the lowest louver has been enlarged to the standard by cutting a double bevel on the lower rail of the frame.

Kassner's recent suggestion (Met. Ztschr. 1912, **29:** 32,428) to leave a space between the two strips of each double louver is hardly essential since the vertical air motion, upon which the proposition is based, occurs only under extraordinarily unfavorable circumstances as compared with the horizontal movements. However, it

[7] A lighter stick stretches from the center of this front crosspiece to the summit of the front edge of the screen.

[8] In the equatorial pattern this is replaced by a second crosspiece attached to the rear edge of the screen and at the level of the roof of the louvred shelter.

[9] *Fenwick W. Stow* reports that during June and July, 1873, in England, the mean daily maxima in a louvered shelter *open beneath*, were 0.8°C. higher than corresponding readings in a similar shelter with a floor (Qtly. jour., R. Met. Soc., London, 1874–5, 2:50).

might be advantageous during still days to allow the warm air which gathers in the angles of the lowest double louvers during calm intervals, to escape above out of the vicinity of the receiving parts of the instruments before the next wind puff drives it against them. But, since the louvers warp out of shape more readily when they do not meet at right angles, a number of holes bored in the upper part of the slats are preferable to the long gap.

Both the louvered shelter and its support must be painted with a bright-colored oil paint. Since I have not found any data* on the heating of wood when painted with various materials, I have myself made several such experiments. I took a number of small cylindrical blocks, as nearly alike as possible, bored out the center and filled it with mercury and inserted therein the bulb of a thermometer. The blocks had received three coats of an oil paint, except the black one which received a soot coating. The blocks when thus prepared were exposed to intense sunshine between double windows for the prevention of draft. Under these conditions the rather thinly soot-covered billet attained a temperature about 6°C. higher, and those painted with ócher and venetian red [Totenkopf] a temperature about 4°C. higher than that reached by the block painted with white lead. The heating of the block coated with glazurit (zinc-white and dammar varnish) was still less, although this block differed by only 0.3°C., in the mean, from the block with white-lead coating. The old observations of Melloni, according to which white lead has the same radiating and absorbing power as lampblack, must therefore, be based on error.

Within the shade screen the louvered shelter rests on two horizontal sticks running east and west; the southerly one is 32 cm. distant from the southern post, and the northerly one is about the width of the shelter farther in front. The small-sized shelter will be placed in the center of the arched screen roof; the large shelter, however, will be placed to the left so that the center of the screen falls in the middle between the dry thermometer and the thermograph element, while the left-hand side of the shelter containing the clockwork stands farther to the left than does the right-hand side to the right. In our latitudes at the height of summer the evening sun grazes the left-hand side of the shelter without seriously affecting the instrument parts (drum and recording pens) there located. The right-hand side containing the psychrometer is much more in need of protection.

The cross supports in the shade screen for latitudes 10° N.–10° S., must be set so far toward the nearest pole, that the door side of the shelter is only 40 cm. from the chord of the corresponding edge of the screen, while the rear wall is fully 65 cm. from the other screen edge (in the small shelter each of these distances is increased by about 4½ cm.). With such an exposure the shelter, even at lat. 10°, can never be reached by the high sun.

In climates with very strong radiation, if the position of the thermometer in the shelter becomes notably affected—say more than 0.2°C.—by the rays of a sun standing even lower than 20°, the matter should be remedied by using a movable screen that will not interfere with ventilation, rather than by bringing the fixed screen down lower. Such a movable screen may well be a strip of coarsely woven bagging 25 cm. wide and ½ to 1 m. long. Wooden strips are tacked on at its upper edge and across its middle, between which points the bagging is doubled, but it is single and merely hemmed at its bottom edge. Two screw hooks in the marginal stick serve to hang it to the lower edge of the shade screen. The 2 mm. meshes of the sacking let the air flow through and give a half-shadow which gets denser as the sun ascends; the wind can lift the under edge of this curtain. After making an observation, this curtain is hung on that side on which the sun will shine from that time to the next observation.

It is often necessary, in order to secure good temperature readings, to place the thermometer shelter where it will be necessary to guard it from mischievous persons. For this purpose wire netting of 10 cm. mesh can be stretched from the under edge of the screen roof to the ground, with a door of the same material between the two north posts.

C. Instruments.—The question of artificial ventilation will be further considered when discussing the psychrometer. Here I wish to express only the wishes (1) that the smallest division of the scale be not less than 0.8 to 1.0 mm.; (2) that the thermometer bulbs be made as small as is consistent with such scale dimensions. If it is desired to have, for example, a thermometer reading to $\frac{1}{5}$ degree, the degree should be 4 to 5 mm. long; on the other hand if one adopts a thermometer reading to $\frac{1}{2}$ or a whole degree (and after a little practice in estimating, such scales are almost equally accurate) then this thermometer should have preferably a cylindrical and a smaller bulb than is now usual in Germany, in order that it may rapidly follow the changing temperature and have a slight radiation error.

Stations of the first order will also have self-recording apparatus for air temperature and air moisture. If this apparatus is as good as it can and should be made to-day, then the maximum and minimum thermometers and the hair hygrometer can be omitted. If they be desired, however, then they should be placed in a separate, similarly screened shelter, and not be allowed to cause an unnecessary increase in size of, or obstruction to the ventilation of the shelter. It must not be forgotten that while the extreme thermometer can indeed be read very accurately to $\frac{1}{10}$ degree, this accuracy is illusory. The errors due to radiation and local factors of the thermometer exposure are trifling in the daily mean temperature, but *are at their largest in the extreme temperatures.*

Thermohygrograph.—Mr. Constans Schneider, of Hamburg, has built a suitable thermohygrograph to meet the requirements I have given. It traces on a relatively large scale in ink (1° C. = 2 mm.; 1 per cent humidity = 0.5 mm.; for one revolution[10] in 3½ days, 1 hour = 3⅓ mm.) on coördinate paper fixed on a drum. The coördinates are rectangular and in a system of the inventor's, that has already been successfully used on many barographs.

[10] There is a great lack of uniformity in the dimensions of self-recording instruments, particularly among those for the smaller stations, due notably to the varying selection of 1-day and 7-day record cylinders. Experience has shown that a legible and readily decipherable meteorogram must have 1 hour on the time scale correspond in length to the space of 1 or 2 degrees (cent.) on the temperature scale. If $1^h > 2°$, the thermogram is too flat and the paper consumption needlessly large; if $1^h < 1°$, the curve is too steep and then in order to read the time satisfactorily one must have immoderately large pen deflections and hence must use Bourdon tubes in place of the cheaper and more durable bimetallic thermal element. The bimetallic element readily gives the quite adequate pen deflection of 2 mm. per centigrade degree. This would allow about 3 mm. for 1 hour on the time scale so that a drum 30 cm. in circumference, such as has stood the test for kite meteorographs, would easily hold records for 3½ days when allowing 3⅓ mm. per hour after keeping a reserve space of 15 mm. for a possible 4½ hours additional record and 5 mm. dead space for the bar of the paper clip. Such dimensions would probably require most stations to change the sheets Mondays, in the morning, and Wednesdays, in the evening. This time scale is exactly twice that of the small-model Richard, whose records, although popular for general purposes, are of limited scientific applicability for the very reason that their time scale is so small.

In the case of the hygrogram, it is sufficient to have 1 per cent = 0.5 mm. A large scale requires too great a magnification. A perfectly uniform sale for the hygrograph requires such an amount of adjusting, and so increases the price of the instrument, that it is better to accept only approximate uniformity in that region of the scale above 60 per cent and to prepare individual graphical correction curves for each instrument after standardizing it.—*Author.*

* See *Coblentz, W. W.*, Diffuse reflecting power of various substances. Bull., U. S. Bureau of Standards, 1912, v. 9 (Reprint No. 196.)

Hanging pens 36 mm. long are suspended obliquely at the end of the pen-arms, and glide along a perpendicular rod of rhombic cross section, being held against it by their own weight. This system has not as yet been tested in the open. The recording drum is held in place on the clockwork by friction only. It is protected from moisture by a square tin case whose front and left side are hinged, door-like, to the rigidly fastened back and right side, and can be swung open when the cover is lifted. The clockwork within the recording drum is further protected by a waterproof case. To change the record-sheet the fresh strip is stretched over a duplicate drum in the house; then the board upon which the apparatus stands is turned round, the case opened, the old drum lifted out and replaced by the new one, and the two pens charged with ink if necessary. The clock is wound without a key, while the case is closed, by means of a ratchet wheel whose lever sticks out from beneath the case and is moved back and forth. Thus the instrument need not be moved from its place in the shelter for any of these operations. The elements are a hair hygrometer and a bimetallic thermometer, built by C. Schneider himself, who has had much experience in making them for the kite and balloon instruments of the Hamburg kite station. The transmission mechanism of the hair hygrometer is adopted from the Richard kite meteorograph. It has the advantage of permitting a fairly uniform scale, but also the disadvantage that the transmission consumes a large amount of the little force available. The entire frame of the apparatus is made of nickel aluminum.

Figure 4 shows the thermohygrograph open. In later examples the hygrometer hairs will be longer and placed under the base-plate beside the thermometric element.

For second-order stations without registering apparatus, the dimensions of the louvered shelter are so chosen that the bulbs of the psychrometer and of the maximum and minimum thermometers stand off about 5 cm. from the louvers. Accurate observations are needed to determine whether, as some contend, the louver walls at this distance can affect the temperature readings. If the inner louvers have a temperature noticeably different from that of the air outside the shelter, then the temperature of the air in the shelter also will be incorrect. I believe that this danger is avoided by the arrangement here proposed whereby no strong radiation can fall upon even the outer louvers. The thermometers lie with their upper ends in wire rests which are inserted in notches cut in the inner louvers of the west side of the shelter; near the bulb-ends stands a vertical wooden rod carrying strong wire hooks as supports which permit the shifting[11] of the maximum and the minimum thermometers according to the change of season, in conformity with the instructions of the Prussian Meteorological Institute. * * *

If it is desired to place also a hair hygrometer in the shelter, then the space above and to the right should be chosen for it, in order to affect all four thermometers as little as possible. According to its mounting, it may either be hung behind the thermometers, or placed on a thin board. The inner louver in this place can be omitted.

D. Artificial ventilation.—The question of artificial ventilation comes up, primarily, in connection with the wet-bulb thermometer, because it there has a double task, viz, both to protect against radiation—as in the case of the dry-bulb—and particularly to make possible the use of a uniform psychrometric constant, because under the varying ventilation of nature that constant, strictly speaking, should be changed as the ventilation varies. For this purpose, the Assmann "Psychroaspirator" (price 45 marks) is already in wide use in Germany. In applying this aspirator to louvered-shelter exposures it is advisable to lengthen the originally short tube between the wet bulb and aspirator[12] until it passes out through the lateral louvers, in order that the shelter may be kept closed from the time aspiration begins to the time of reading.

With such a powerful air current at hand (in present psychroaspirators it amounts to about 3 m/sec.) it is but a step to extend its use to the ventilation of the dry-thermometer in those cases of calm weather and strong radiation where natural ventilation is insufficient; and simply by bringing both bulbs into the same current. I have experimented in this line; but since a similar modification of Assmann's aspiration apparatus will shortly be described by Assmann himself, I shall not go further into this matter.

Since a convincing test of the new thermometer screen must be made in a climate of strong radiation, Dr. C. Dorno in Davos has most kindly undertaken to compare it over a long period with the Assmann aspirated thermometer and the English shelter. The instruments and also the screens were contributed for this purpose by the Prussian Meteorological Institute and the German Seewarte. Similar comparisons will be instituted at the Hamburg kite station, whose predominantly cloudy and windy weather makes, indeed, much less demands upon protection from radiation, although not less than does the native weather of the English screen itself.

[11] The maximum and minimum thermometers of the Prussian Institute lack the metal backs of the United States Weather Bureau instruments, and they lie horizontally in metal brackets in front of the vertical wet- and dry-bulb thermometers hanging behind them. The bracket with the maximum and minimum is shifted with the seasons, to avoid interfering with readings of the wet- and dry-bulb thermometers.—C. A., jr.

[12] Meteorol. Ztschr., Wien, Jan., 1891, 8:18.

WEATHER BUREAU TERMS USED TO DESIGNATE STORMS.

[Dated: Weather Bureau, Sept. 25, 1915.]

Cyclone.—As used by the Weather Bureau the term "cyclone" is the name of any atmospheric system in which the barometric pressure diminishes progressively to a minimum value at the center, and toward which the winds blow spirally inward from all sides. The system overspreads an approximately circular or elliptical area at least 50 miles, generally several hundred miles, and often over one thousand miles in diameter. A cyclone is any such system of winds, except a tornado which is rarely greater than a mile in diameter, or a whirlwind which is seldom more than a few yards across. North of the Equator the inflowing winds move in a counterclockwise direction. South of the Equator the spiral inflow is clockwise in direction of motion. The name does not signify any degree of intensity, and is applied to storms of little as well as to those of great intensity. On weather maps cyclones appear as systems of a few or many closed concentric isobars of elliptical or nearly circular form, and indicate a progressive decrease in the atmospheric pressure to a minimum at the center. Arrows showing the direction of the wind indicate a gyratory inflow from all sides.

Classification.—For purposes of analysis and technical discussion cyclones may be divided into a great many classes. For the purposes of forecasting, non-technical

bulletins and the like publications, seemingly the most satisfactory basis of classification is that of geographic origin, according to which two main groups suffice, "Tropical" and "Extratropical."

Tropical cyclones of greater or less intensity possess characteristics which differentiate them, in a measure, from cyclones of extratropical origin having approximately equal intensities, yet the essentials of both groups are practically the same.

Hurricane; Typhoon.—Special terms have been employed to designate tropical cyclones in various parts of the world, especially when fully developed and exhibiting destructive intensity. The word "cyclone" was first applied to violent disturbances of cyclonic character in the Bay of Bengal; but to a similar disturbance originating 1,000 to 2,000 miles to the eastward, as in the China Sea or the region of the Philippines, the name "typhoon" is frequently applied. In the tropical seas to the southeastward of the North American Continent the name "hurricane" is applied, and this disturbance is given the additional qualifying words "West Indian," evidently to indicate its location or place of origin.

In Weather Bureau usage, therefore, the name "West Indian Hurricane" is specifically applied to fully-developed tropical cyclones which originate and exhibit destructive violence in the West Indies or adjacent regions. A West Indian hurricane can cause great damage because of wind effects, because of great volumes of precipitation, by unusual tidal conditions, or by combinations of these and other accompanying characteristics. The word "hurricane" is also used in other combinations, and then has a different signification. For example "hurricane" is the highest force on the Beaufort wind scale. Winds of "hurricane force" are considered to have actual velocity of 75 miles per hour or more, and winds attaining such speed are said to blow with hurricane force, irrespective of geographic locality or whether the winds are associated with a cyclone of West Indian origin.

Tropical cyclones of the West Indies, as well as of other portions of the Tropics, occasionally pass into extratropical regions. The question may then be asked, "How shall a tropical cyclone or a West Indian hurricane or a typhoon be classed after it has passed into extratropical latitudes"? Tropical cyclones change in important particulars when they leave the warm, humid equatorial regions and come under the influence of conditions prevailing in the Temperate Zone. Such changes, however, take place gradually, and a tropical cyclone may show great intensity even several degrees north of the Tropic of Cancer, especially when traveling over water. While moving inland over the North American Continent, however, they show marked signs of waning intensity and soon become indistinguishable from cyclones of actual extratropical origin.

In a bulletin issued by the Weather Bureau, entitled "The West Indian Hurricane of August 13–23, 1915," the track of that great storm is shown from its first appearance in the vicinity of Martinique to its practical dissipation in the Gulf of St. Lawrence.[1] While in a connection of this character the term "West Indian hurricane" may be appropriately applied to this great storm at any point of its course, nevertheless to do so does not in that case necessarily imply that at every point of its path the storm exhibited destructive violence. Similarly, throughout its course the storm may properly be designated a "tropical cyclone," as the observations available show its tropical origin. In the absence of such knowledge the same storm in temperate latitudes would be named an "extratropical cyclone."

Tornado.—This name is applied to certain storms of well-known characteristics. While they occur in connection with certain cyclonic systems and exhibit great intensity, they are, nevertheless, of extremely local geographic extent and of very short duration.

[1] Also on chart XLIII—92 of the present issue of this issue of the REVIEW—C. A., jr.

NOTE ON THE CRUSHING OF A COPPER TUBE BY LIGHTNING.

By W. J. HUMPHREYS, Professor of Meteorological Physics.

[Dated: Weather Bureau, Washington, D. C., Sept. 1, 1915.]

Introduction.—Although the collapse of a hollow lightning rod under the stress of a heavy discharge has already been described and explained,[1] the phenomenon appears to be of unusual occurrence and not very generally known. It may, therefore, be worth while to discuss in some detail an excellent example of a crushed lightning conductor kindly furnished for this purpose by Mr. West Dodd, of Des Moines, Iowa.

In a letter dated April 5, 1915, Mr. Dodd, referring to the conductor in question, says:

> The crushed tube was 5 feet long. It constituted the entire part that stands on top of the house for the point.
>
> The rest of the rod was copper cable and about 50 to 100 feet of that was crushed into smaller volume or made smaller in diameter, as it was loosely woven.
>
> This happened in Michigan about six years ago, and the house was not damaged any—not even a splinter taken off.
>
> Similar phenomena of this kind have occurred in four or five instances to my knowledge, but in the great majority of cases where a point is melted the tube is not damaged.

An additional reason for discussing this particular example of the effect of the "pinch phenomenon"[2] is the fact that it offers data sufficient for making a rough estimate of the current strength of the discharge, and even a crude estimate of the quantity of electricity involved.

Description of conductor.—Figure 1 shows two originally duplicate (so reported), hollow, copper lightning rods, one uninjured (never in use), the other crushed by a discharge. The uninjured rod consists of two parts, shown assembled in figure 1 and separate in figure 2. The conical cap, nickel plated to avoid corrosion, telescopes snugly over the top of the cylindrical section, and when in place, where it is left loose or unsoldered, becomes the ordinary discharge point.

The dimensions are:

Section.	Outside diameter.	Inside diameter.
	Millimeters.	*Millimeters.*
Cylinder	16.0	14.65
Cone shank	17.4	16.0

Length of conical cap, cylindrical portion, 7 cm., total, 19 cm.

Both the cylindrical and the conical portions of the rod are securely brazed along square joints.

Effects of discharge.—The general effects of the discharge, most of which are obvious from the illustrations, were:

1. One or two centimeters of the point were melted off.

[1] *Pollock & Barraclough.* Jour.-Proc., Roy. soc., N. S. Wales, 1905, **39:** 131.

[2] For the origin of this term, now widely used, and a general discussion of the phenomenon, see *Northrup,* Phys. Rev., 1907, **24:** 474; Trans., Amer. electrochem. soc., 1909, **15:** 303.

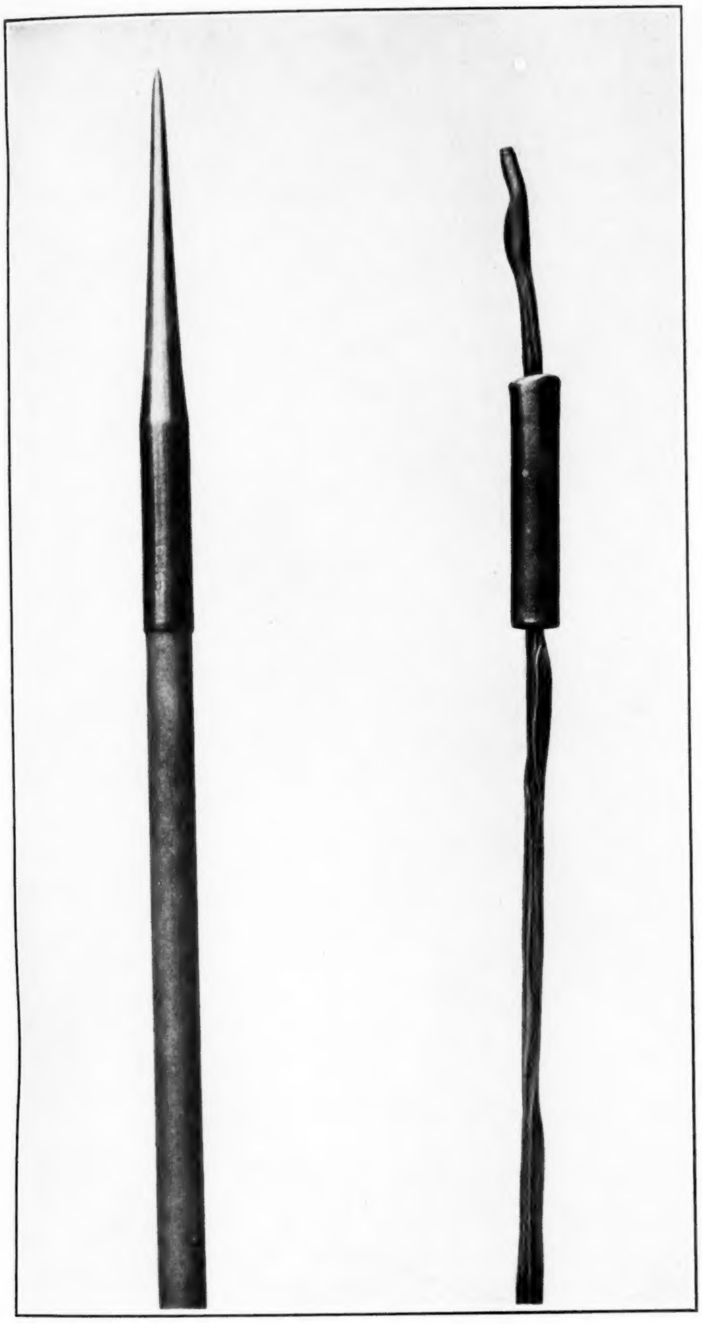


FIG. 1.—Originally duplicate hollow copper lightning rods. Rod on the left never in use; rod on the right crushed by a lightning discharge.

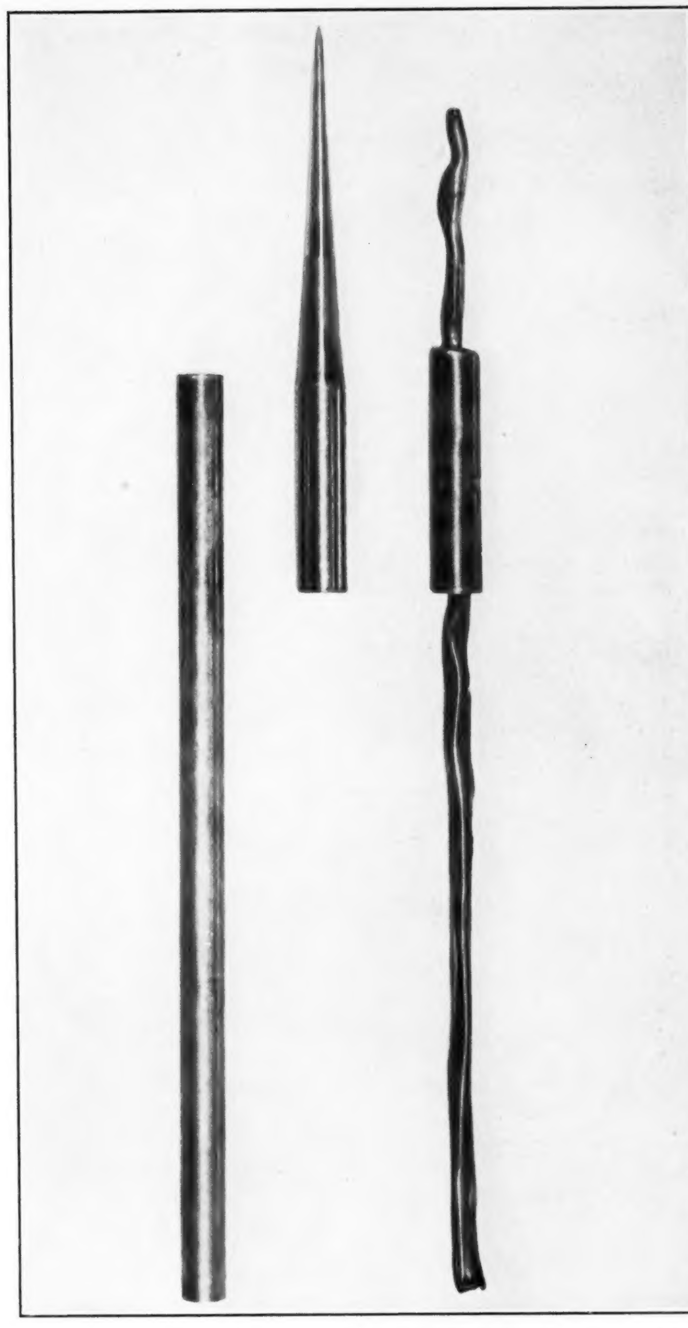


FIG. 2.—Originally duplicate hollow copper lightning rods shown in figure 1, but not assembled.

2. The conical portion of the top piece and all the cylindrical rod except the upper 2 centimeters, roughly, within the cap were opened along the brazed joint.

3. The brazing solder appears to have been fused and nearly all volatilized, as only patches of it remain here and there along the edges.

4. The upper end of the cylindrical rod was fused to the cap just below its conical portion.

5. The rod was fused off where it passed through a staple. Whether a bend in the conductor occurred at the place of fusion is not stated.

6. The collapse of the cylindrical rod extended up about 5 centimeters into the cap.

7. The cylindrical portion of the cap, about 7 centimeters in length, was uninjured; even the brazing was left in place.

Cause of collapse.—What force or forces caused the collapse of the rod? Possibly it might occur to many that it was produced by the reaction pressure from an explosionlike wave in the atmosphere, due to sudden and intense heating. But however plausible this assumption may seem at first, there, nevertheless, are serious objections to it, some of which are:

1. While explosions with their consequent pressure may be obtained by passing a powerful current along a conductor, they seem to occur only on the sudden volatilization of the conductor itself, which in this case did not take place.

2. The heating of the air inclosed by the rod should have produced a pressure from within more or less nearly equal to the pressure simultaneously caused from without, and thereby have either prevented or at least greatly reduced the collapse.

3. The assumption that the crushing of the conductor was due to mass inertia of the suddenly heated air offers no solution whatever of the collapse of the portion of the rod within the shank of the cap.

For these reasons the idea that the collapse of the conductor may have been caused by the reaction pressure of an explosion wave in the atmosphere due to sudden heating, seems to be untenable.

Probably the explanation of the collapse already offered by Pollock and Barraclough at least involves an important factor, if it is not wholly correct. It is as follows: Each longitudinal fiber, as it were, of the conductor attracted every other such fiber through the interaction of the magnetic fields due to their respective currents, and the resulting magnetic squeeze on the hollow rod, whose walls were weakened by the heating of the current, caused it to collapse as shown in figures 1 and 2 opposite.

As is well known the force f in dynes per centimeter length, with which a straight wire carrying a current of I amperes is urged at right angles to the direction of the lines of force of a uniform magnetic field of intensity H, is given by the equation,

$$f=\frac{IH}{10}.$$

Also the value of H at a point r centimeters distant from a relatively very long straight conductor carrying I amperes, is given by the relation,

$$H_r=\frac{2I}{10r}.$$

Now, as developed by Northrup[3] in the theory of his heavy-current ammeters: let a, figure 3, be the outer and b the inner radius of a tubular conductor, and let r be the radius of any intermediate tube of infinitesimal thickness, dr. Also let the conductor as a whole carry a uniformly distributed current of I amperes. Then the value of the magnetic force, at the end of the radius r, is given by the equation

$$H_r=\frac{2I(r^2-b^2)}{10r(a^2-b^2)},$$

which depends upon the fact that only those portions of the current less than r distant from the axis are effective—the forces due to the outer portions neutralizing each other. Also the strength of the current dI, carried by the cylinder of radius r and of infinitesimal thickness dr, is given by the relation,

$$dI=\frac{2Irdr}{(a^2-b^2)}.$$

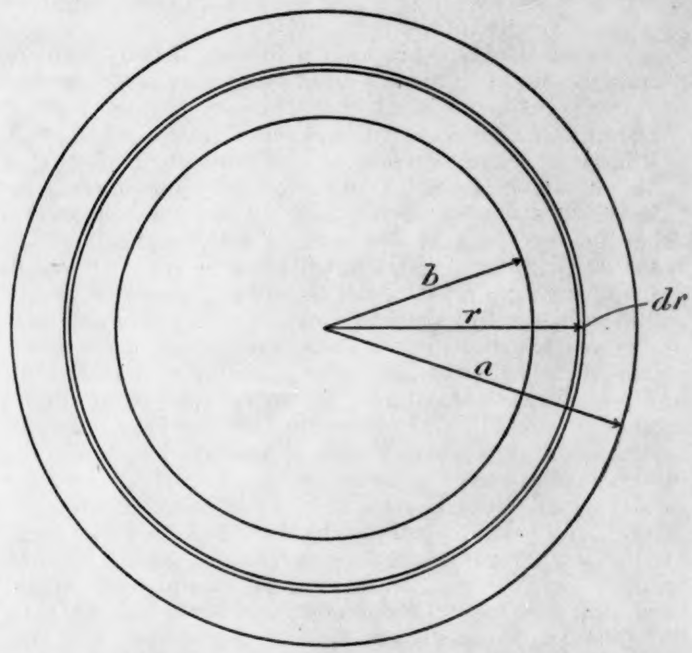


Fig. 3.—Section of a tubular conductor, of outer radius a and inner radius b; r, radius of any intermediate tube of infinitesimal thickness, dr. The conductor as a whole carries a uniformly distributed current of I amperes.

Hence under the assumed conditions, the normal pressure, dP, per unit area on the cylinder of radius r and thickness, dr, may be determined by the equation,

$$dP=\frac{2Irdr}{2\pi r 10(a^2-b^2)}\times\frac{2I(r^2-b^2)}{10r(a^2-b^2)}.$$

Hence the total normal pressure, P, per square centimeter of the *inner* surface is given by integrating the above expression between the limits b and a. That is:

$$P=\frac{2I^2}{100\pi(a^2-b^2)^2}\left(\int_b^a r\,dr-b^2\int_b^a\frac{dr}{r}\right)$$

$$=\frac{2I^2}{100\pi(a^2-b^2)^2}\left[\tfrac{1}{2}(a^2-b^2)+b^2\log_e\frac{b}{a}\right]$$

$$=\frac{I^2}{100\pi(a^2-b^2)}\left(1+\frac{2b^2}{a^2-b^2}\log_e\frac{b}{a}\right).$$

[3] Trans., Amer. electrochem. soc. 1909, 15:303.

Substituting for a and b their numerical values, 0.8 cm. and 0.7325 cm., respectively, it is found that,

$$P = \frac{I^2}{379.1}$$

If we assume P, the pressure in dynes per square centimeter of the inner surface to be 10^6 or approximately one atmosphere, then $I = 19,470$ amperes, approximately.

If the lightning discharge were alternating the current density would be greatest in the outer portions of the conductor, and therefore the total current would have to be still heavier than the above computed value to produce the assumed pressure. However, it seems probable that the discharge is unidirectional and not alternating,[4] and therefore that the computed strength of current, though of minimum value, is substantially correct.

Estimated charge and strength of current.—To determine the amount of electricity involved in a lightning discharge it is necessary to know both its duration and the average strength of current. Both factors and, therefore, the total charge are known to vary greatly, though actual measurements have been comparatively few and even these, as a rule, only crudely approximate.

It has often been stated that the duration of a single discharge, or single component of a multiple discharge, is not more than 1/1,000,000 of a second. Some have computed a duration of roughly 1/100,000 of a second, while others have estimated that it can not be greater than 1/40,000 or, at most, 1/35,000 of a second. Possibly many discharges are as brief as some of these estimates would indicate, but there is ample reason to believe that others are much longer. Thus one occasionally sees a streak of lightning that lasts fully half a second without apparent flicker, while more or less continuous or ribbon discharges are often photographed by moving cameras. But in addition to these evidences we have also a number of time measurements made by Rood[5] with a rotating disk, ranging from less than 1/1,600 second up to 1/20 second, and others, 38 in all, by De Blois[6] with an oscillograph, ranging from 0.0002 second to 0.0016 second. In one case De Blois found the durations of five sequent discharges to be 0.0005, 0.0015, 0.0016, 0.0014, and 0.0012 second, respectively, or 0.0062 second as the summation time of these principal components of the total discharge. Hence it seems probable that the actual time of a complete discharge, that is, the sum of the times of the several components, may occasionally amount to at least 0.01 second.

The second factor, the strength of discharge, is even more difficult to determine, and but few estimates of it have been made. Pockels,[7] adopting the ingenious method of measuring the residual magnetism in basalt near a place struck by lightning and comparing these quantities with those similarly obtained in the laboratory, concluded that the maximum strength of current in such discharges amounted occasionally to at least 10,000 amperes. However, the loss of magnetism before the measurements were made, and other unavoidable sources of error, indicate that the actual current strength was much greater than the estimated value—that the maximum strength of a heavy lightning discharge certainly amounts to many thousands of amperes, occasionally perhaps to even one hundred thousand.

[4] *Humphreys.* MONTHLY WEATHER REVIEW, June, 1914, **42**: 377. *Marvin*, idem, August, 1914, p. 499–501.
[5] Amer. jour. sci., 1873, **5**: 163.
[6] Proceedings, Am. inst. elec. eng., 1914, **33**: 568.
[7] Annalen d. Phys., 1897, **63**: 195; 1898, **65**: 458; Met. Ztschr., 1898, **15**: 41; Phys. Ztschr., 1901, **2**: 306.

Since the above estimates are very rough it would seem well to check them, even though the check itself be equally crude. Hence it may be worth while further to consider the crushed lightning rod with this particular object in view.

From the dimensions of this rod, outside diameter 1.6 cm., inside diameter 1.465 cm., it follows that its cross-sectional area is about 0.325 sq. cm., and its weight, therefore, approximately 2.9 grams per centimeter. Further, from the fact that the brazed joint was opened and most of the solder removed—apparently volatilized—and the further fact that the condition of the rod itself in several places indicates incipient fusion, it would seem that the final temperature may have been roughly 1,050° C. If so, the rod must have been heated about 1,025° C., since its temperature just before being struck probably was approximately 25°C. But the average specific heat of copper over this temperature range is roughly 0.11, and therefore about 327 calories per centimeter were generated.

Now one ampere against one ohm generates 0.24 calories per second. Hence, since the resistance[8] of the uninjured or check rod is practically that of pure copper, the average resistance of the crushed conductor over the assumed temperature range probably was about 17 microhms per centimeter length,[9] we have the equation,

$$\frac{24}{10^2} I^2 \frac{17}{10^6} t = 327,$$

in which I is the average strength of current, and t the actual time of discharge. Assuming $t = 0.01$ second we get, roughly,

$$I = 90,000 \text{ amperes.}$$

A current of this average value would indicate a maximum value of perhaps 100,000 amperes.

It was computed above that a current of 19,470 amperes in the given hollow conductor would produce on it a radial pressure of 10^6 dynes per square centimeter or about one atmosphere. Hence 100,000 amperes would give a pressure of 2638×10^4 dynes per square centimeter, or approximately 400 pounds per square inch; enough, presumably, to produce the crushing that actually occurred.

A current of 90,000 amperes for 0.01 second would mean 900 coulombs, or 27×10^{11} electrostatic units of electricity; certainly an enormous charge in comparison with laboratory quantities, but after all a surprisingly small amount of electricity, since it would electrolyze only 0.084 of a gram of water. It must be clearly kept in mind, however, that these estimates are exceedingly rough and that at most they only tend to confirm certain previous estimates in regard to the lightning discharge, namely, that in some cases the strength of current probably amounts to many thousands of amperes, and that the total duration of the individual or partial discharges may be several thousandths of a second.

A NOTE ON THE RELATION OF CLIMATE TO AGRICULTURE IN CALIFORNIA.

By ANDREW H. PALMER, Observer.

[Dated Weather Bureau, San Francisco, Cal., Aug. 1, 1915.]

It has been remarked that in the climatic conditions affecting agriculture California shows an epitome of the whole United States, with added climatic characters peculiarly her own. Indeed the statement might have

[8] Measured by the U. S. Bureau of Standards.
[9] *Northrup*, Jour. Franklin inst., 1914, **177**: 15.

been made more inclusive. With the sole exception of those tropical conditions which involve continuous high temperature and excessive humidity, California has samples of the climates of every part of the world which permit successful agriculture. An enumeration of her fruits alone is a catalog of the known fruits of the world, with the exception of those strictly tropical. This is also true of certain individual counties, which in several instances are larger than whole states.

Throughout the greater part of the United States the strictly agricultural pursuits associated with the cultivation of the soil are limited to the summer half-year. In California the period from January 1 to December 31, inclusive, constitutes the agricultural period. It is no exaggeration to say that crops are growing and maturing all the time within the State. Residents of other States sometimes have difficulty in realizing these facts. From the point of view of the consumer they are interested primarily in the harvest period. At the request of Mr. G. H. Willson, Section Director, U. S. Weather Bureau, San Francisco, Cal., Prof. E. J. Wickson, of the Agricultural Experiment Station, College of Agriculture, University of California, and one of the leading authorities on the subject of agriculture in this State, has compiled a summary of the usual time of harvesting the principal crops in California. This compilation, which takes account only of the time of harvesting of the crop directly from the plant or from the open ground in which it grew, is as follows:

Almonds—August and September.
Apples—June to November.
Apricots—May to August.
Artichoke (globe)—October to May, for commercial crop. Continuous, for garden crop.
Artichoke (Jerusalem)—November to March.
Asparagus—January to May.
Barley—May to August.
Beans (dry)—August to November.
Beets—Throughout the year.
Cabbage—Throughout the year. (Chief commercial, Jan. to Apr.).
Cantaloups—May to October.
Carrots—Throughout the year.
Celery—Throughout the year. (Chief commercial, Nov. to Feb.)
Cherries—March to July.
Corn—August to October.
Cotton—June to November.
Cucumbers—May to November.
Figs—June to September.
Grapes—July to December.
Hay (alfalfa)—March to December.
Hay (grain hay)—April to June.
Hops—August to September.
Lemons—Throughout the year. (Chiefly Feb. to Aug.)
Oats—June to September.
Olives—November to January.
Onions (green)—Throughout the year.
Onions (dry)—July to November.
Oranges—Throughout the year. (Chiefly Dec. to Aug.)
Peaches—May to November. (Chiefly Aug. and Sept.)
Peas (green)—Throughout the year.
Peas (field peas)—May to August.
Pears—July to November.
Peppers (green)—Throughout the year.
Peppers (crop for drying)—September and October.
Plums—June to October.
Potatoes—Throughout the year. (Chiefly July to Nov.)
Potatoes (sweet)—August to October.
Prunes—July and August.
Rhubarb—Throughout the year, with summer and winter varieties.
Rice—September to November.
Rye—June to August.
Sorghum (grain varieties)—July to September.
Spinach—Throughout the year.
Squashes and pumpkins—August to November.
Sugar-beets—July to November.
Tomatoes—Throughout the year.
 Table crop—June to November.
 Canning crop—August to October.
Turnips—Throughout the year.
Walnuts—September and October.
Watermelons—June to September.
Wheat—May to August.
Wool—Two clips; March and September.

It is apparent from the above that in California there is a continuous seedtime and harvest for something, and that there is but occasional coincidence with eastern crop periodicity. In his book, "California Fruits," Prof. Wickson has also pointed out why, from an agricultural point of view, there are wider differences within its borders than are found in a long sweep of States from the Gulf of Mexico to Canada. An enumeration of some of the principal facts in the relation of climate to agriculture in California, together with a brief explanation of some of these facts, is given in the following:

In latitude California extends from 33° N. to 42° N., corresponding roughly to that from Charleston, S. C., to Boston, Mass., on the Atlantic side of the continent. Its coast line runs northwest-southeast, not north-south, as many imagine. Owing to the proximity of the Pacific Ocean and the prevailing westerly direction of its winds, the isotherms run north-south, not east-west, as in the interior of the continent. The mean annual temperatures range from 42.1°F. to 76°F., while extremes of −21°F. and 134°F. have been recorded in different parts of the State in the same year. The mean annual precipitation ranges from 2 to 113 inches, with extremes at different stations ranging from no rainfall to 154 inches. Altitude above the sea level rather than latitude controls the temperature, while altitude together with latitude control the precipitation. The southern and lower parts of the State are drier than the northern and higher portions. Summer and winter are terms synonymous with dry and wet periods, respectively, rather than with hot and cold periods. Most of the precipitation is of cyclonic origin, and since cyclones dominate the winter only the agricultural portion of the State receives more than 90 per cent of its rainfall during that season. Generally speaking, topography is of more importance as a control of climate than is latitude.

The agricultural significance of these facts is evident in a great variety of ways. The terms "northern" and "southern" have little climatic, and no agricultural, application in California. Northern fruits reach perfection, under proper conditions, at the south, and vice versa. In the words of Prof. Wickson, "The apple and the orange, fruit kings whose kingdoms lie at opposite borders of the Temperate Zone, so far distant that one may be called semifrigid and the other semitropical, have in California utter disregard for the parallels of latitude, which set metes and bounds upon them in other lands, and flourish side by side, in suitable localities, from San Diego to Shasta." Moreover, some fruits can be successfully grown through a north and south distance of 500 miles, but can not successfully be carried through a few hundred feet of either less or greater elevation. Furthermore, the long growing season results in second and sometimes in third crops of considerable commercial importance, while altitude differences make possible a long period during which fresh fruits and vegetables are procurable. Again, some regions of greatest annual rainfall require the most frequent irrigation—a fact dependent upon the rainfall periodicity, as well as upon the character of the soil and the needs of the plant. Some of the interior regions having the highest temperatures also have the most marked valley frosts. Occasionally snow-clad mountains and groves of delicate orange trees are in close juxtaposition laterally, though at different altitudes above the level of the sea.

From the agricultural point of view the climates of California may be classified as follows: (1) Coast climate, (2) valley climate (including foothill climate), and (3) mountain climate. In brief, the characteristics of the coast climate are equable temperature, increasing as one approaches the south; relatively cool summers and relatively warm winters, compared with the interior; abundant rainfall, increasing as one approaches the north; prevailing west winds; and a humid atmosphere, with frequent fogs and overcast skies. The valley climate is one of higher summer and lower winter temperatures than that of the coast, with little north and south differences; high afternoon temperatures in summer and occasional early morning frosts in winter; abundant rainfall in the north and decreasing rapidly toward the south, necessitating irrigation in the interior valleys of the southern half of the State; dry air; almost constant sunshine, with freedom from fogs and from dew in summer time; and with winds occasionally stormy and cold in winter, and hot and desiccating in summer. The foothills include places up to 2,500 feet in elevation. The foothill climate differs from the valley climate principally in the lower midday temperatures in summer, fewer frosts in winter, and a slightly higher annual rainfall, the same increasing regularly with increase of height above sea level. The valley and foothill regions together form the principal agricultural portions of the State. The mountain climate resembles somewhat that of the Eastern States, and is characterized by moderately warm summers and moderately cold winters, without great temperature ranges, however; abundant precipitation, which increases up to a height of 6,500 feet, and decreases beyond that point; and with much of the winter precipitation in the form of snow, the heaviest known in the United States, and one of the principal resources of the State in that it furnishes, upon melting, most of the water used for irrigation and power purposes.

Of the various agricultural activities in the State horticulture is one of the leading, and its importance is increasing year by year. From the point of view of the horticulturist the chief characteristics of California climate are (1) abundance of sunshine, (2) freedom from extremely low temperatures, and (3) an atmosphere with a low per cent of humidity. Temperature is of prime importance in fruit-growing, since not only must the mean annual temperature be sufficiently high but the mean temperature of the various seasons must also be favorable, and there must be no extremely low temperatures at any time. Sunshine is to be considered, since direct and not diffused sunshine is necessary for fructification. Moreover, a considerable amount is needed for ripening some fruits, and still more is necessary for their curing and preserving. In California the humidity, both absolute and relative, is high in winter and low in summer, just the reverse of that in the East. The dry air of summer not only favors the access of light and heat, but it also permits certain chemical actions necessary for fruit ripening. Moreover, a consideration of some moment is the fact that it prevents certain fungoid diseases. The horticultural year begins with the blossoming of the almond trees in January, an event which marks the advent of spring in California. The period of greatest fruit growth is from June to October. The rest period in trees and vines just following the gathering of the fruit is a dry season climatically, not a cold season as in the East. While strong winds are not of frequent occurrence in the agricultural portions of California, those which do occur come during the season when the trees are bare. Furthermore, the soil moisture has its origin in the winter rains, when the trees and vines are inactive, but gathering strength for the coming season.

Further theoretical considerations are unnecessary. Perhaps the best evidence of the favorable characteristics of California climates is seen in the variety, size, quality, quantity, color, and aroma of its fruit. Again using the exact words of Prof. Wickson, "All things considered, it is doubtful whether any area in the world excels California in possession of natural adaptation to fruit production and preservation."

CLASSIFICATION OF AMERICAN SUMMERS.

By HENRY F. ALCIATORE, Section Director.

[Dated: Local Office, Weather Bureau, Reno, Nev., Aug. 17, 1915.]

Climatologies abound, in which the effects of the weather on growing crops, stock raising, irrigation, etc., are set forth at great length and explained, but where can one find a work that deals exclusively with human aspects of climate, such, for instance, as personal comfort and agreeableness, not to mention exhilarating and debilitating characteristics?[1]

Weather Bureau men are sometimes consulted as to the desirability of this or that climate by people interested in but one phase of the subject, namely, How will the climate affect my physical condition and well being?

Should one desire to compare the climate of one place with that of some other place, how would one go about it? Every climatologist knows that expressions like "Mean annual temperature," "Mean annual humidity," are practically meaningless in comparative climatology. To illustrate: The mean annual temperature of Los Angeles and Little Rock are the same, i. e., 62°F., from which circumstance the reader might infer that, so far as temperature is concerned, the two cities have similar climates. Yet it would be difficult to find two more *dissimilar* climates in the Western Hemisphere. Again, Reno and Des Moines have equal mean annual temperatures, but Reno's summers are considerably cooler and more agreeable than are those of Des Moines, and its winters much milder.

Of course, there is the Angot method of comparing the summers and winters of different places. While it is far more satisfactory than the customary "mean temperature" method, still it falls short of satisfactoriness in that it discusses but one climatic element, namely, the deviation of maximum temperatures above an arbitrarily fixed point (87°F.), and minima below 32°F. Obviously, such a scheme is inadequate to express the contrast between the summer climates of Atlantic City, N. J., and Denver, Colo.; their mean summer temperatures are practically the same, but the first named is one of the dampest spots in the country (in summer) while Denver has a dry summer climate. Nor would the Angot method give good results in the case of Phoenix, Ariz., and Fresno, Cal.; both of these cities are practically in the same class as to excessively high day temperatures, but Fresno's nights are cooler and fairly pleasant. We all know that a summer's day in Washington, D. C., when the thermometer registers 90°F., is quite a

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[1] The following are a few among many works that discuss this subject:
Ward, R. DeC. Climate considered especially in relation to Man. London, 1908.
Bebber, W. J. van. Hygienische Meteorologie. Stuttgart, 1895.
Ratzel. Anthropogeographie. Stuttgart, 1899.
Die Erde und das Leben. Leipzig, etc., 1901. 2 v.
Vincent, J. Nouvelles recherches sur la température climatologique. Annales météorol. de l'Observ. roy. de Belgique. N. S., Ann. météorol. t. **20**, fasc. 1.—C. A. jr.

different matter from a day with an equal temperature in Reno; in the first-named city the day would be felt as very warm, sticky, and depressing, while in Reno the weather (owing to dryness) would *feel* moderately warm and not at all uncomfortable.

Climatic elements.—In any method of classifying summers, at least three climatic elements should be considered and each given its proper weight, namely, (1) Frequency of showers; (2) temperature; (3) humidity. The nomenclature employed in expressing these elements should be uniform and free from technical terms.

Summer is, par excellence, the open-air, out-of-door, season. Various activities of a social and health-seeking character spring into life with the return of warm weather —riding and boating parties, picnics and lawn fêtes, Olympic games, etc. In most of these success or failure, enjoyment or disappointment, depend not at all on the probable mean temperature of the festal day; the things that count most are: Will it rain? Is it going to be hot or cool? And, where the projected festivities are to last several days, the consideration of paramount importance is this: What is the average percentage of showeriness for that particular period?

TERMINOLOGY.

For the benefit of those who have to make arrangements for outdoor affairs, as well as for people who are contemplating a change of climate for health reasons or personal comfort, the writer suggests the following as a humanized method of classification of summers, in the hope that it may prove useful and create a greater interest in the subject.

This method takes into account the three climatic elements previously referred to. The numerical values chosen are not at all arbitrary, but are based on personal experience, and have been adopted only after the writer had made a rather exhaustive comparison of a score of typical climates in which, at one time or another, he has lived. Other than convenience, brevity, and uniformity of vocabulary, no claims are made for the method. For describing any summer climate whatever not more than ten ordinary English words and two numerals are sufficient.

Character of the summer.—Only two general heads are needed, i. e., Fair and Showery. However, anticipating possible objections to so sharp a division, it has occurred to the writer to add a numerical suffix expressing the percentage of *fair* days in the first and the percentage of *rain frequency* in the second division. I have found that, on the average, the percentage of showeriness in the habitable portions of the United States is about 28, i. e., of the 92 days of summer (June, July, August), 28 per cent are showery. Therefore a climate with a smaller percentage would be styled Fair, and one with a larger percentage Showery. There would be no confusion. To illustrate:

Shreveport, Fair 73 per cent; Fresno, Fair 99 per cent; Chicago, Showery 32 per cent; and New Orleans, Showery 48 per cent, would be intelligible.

Temperature.—Instead of using *mean monthly* temperatures it is proposed to use the *summer* means of the daily maximum and daily minimum temperatures, independently, to the end that days and nights may be properly differentiated. Thus, in New York, the mean afternoon temperature of summer is about 80° and the mean night temperature 65°. For San Francisco the values are, respectively, 65° in the daytime and 53° in nighttime. Furthermore, the term "alternately warm and cool" might be used for climates with large daily variabilities in those two elements. Chicago (as to day temperatures) and Red Bluff (as to night temperatures) will serve as examples of this class. In August, 1913, Chicago experienced the following thermic eccentricities in successive daily maxima (not at all uncommon): 95° to 72°, a drop of 23°; 86° to 74°, fall of 12°; 82° to 69°, fall of 13°; 93° to 82°, fall of 11°; 83° to 94°, rise of 11°. At Red Bluff, Cal., during the same month, night temperatures were almost as erratic, as the following will show: 63° to 78° to 87°, showing successive, 24-hour variations of 15° and 9°, respectively; that is, from a cool night to a very warm and, then, an intolerably hot one; others were: 79° to 66°, fall of 13°; 66° to 76°, rise of 10°; 78° to 70°, fall of 8°. These climates are better described (as to heat) by the expressions "alternately warm and cool days" and "alternately warm and cool nights."

Moisture or relative humidity.—Here assume that, in the absence of 24-hour hygrometric observations, the mean relative humidity of summer based on 8 a. m. and 8 p. m., 7 a. m. and 7 p. m., 6 a. m. and 6 p. m., and 5 a. m. and 5 p. m. local-time readings, will answer all practical purposes.[2] The fact that the humidities of Phoenix and Atlantic City are in the ratio of 32 per cent to 86 per cent will stand whether we use the means of hourly observations or those of twice-daily readings. These percentages probably represent the extremes of summer dryness and dampness for the United States. The four divisions into which we propose to classify the moisture factor of climates, i. e., Very dry, Dry, Damp, Very damp, will be based on the semi-daily hygrometric values used by the Weather Bureau.

The vocabulary and its numerical equivalents are given in Table 1.

TABLE 1.—*Proposed climatographic vocabulary.*

CHARACTER OF SUMMER.

Fair, 0 to 28.5 per cent of rainy days.
Showery, 28.6 to 100 per cent of rainy days.

DAY TEMPERATURE.	°F.
Very cool	50 to 75
Cool	76 to 85
Warm	86 to 94
Hot	95 to 125

NIGHT TEMPERATURE.	
Very cool	35 to 55
Cool	56 to 65
Warm	66 to 70
Hot	71 to 85

RELATIVE HUMIDITY.	Per cent.
Very dry	0 to 45
Dry	46 to 65
Damp	66 to 75
Very damp	76 to 100

Provided with a vocabulary and the necessary climatic data[3] we may now proceed to test our method by classifying ten different summer climates, each one of which shall typify some particular climatic condition and at the same time acquaint the reader with some of the amazing contrasts of summer climates in the United States. That

[2] This assumption seems altogether too violent. The apparent necessity for it in dealing with United States data is regrettable.—C. A., jr.

[3] *Henry, Alfred Judson.* Climatology of the United States. Washington, 1906. (Weather Bureau, Bul. Q.)

this may be done in an orderly fashion I shall group these typical climates in the following order:

Driest.
Dampest.
Hottest days.
Hottest nights.
Coolest days.
Coolest nights.
Most sunshiny.
Most showery.
Variable day temperatures.
Variable night temperatures.

TABLE 2.—*Typical American summer climates described in Alciatore's terminology.*

Modena, Utah...	Fair.......	86 per cent warm days.	Very cool nights....	Very dry.
Atlantic City, N. J.	Showery..	32 per cent cool days.	Cool nights..........	Very damp.
Phoenix, Ariz...	Fair.......	87 per cent hot days.	Hot nights...........	Very dry.
Galveston, Tex..	Showery..	29 per cent warm days.	Hot nights...........	Very damp.
San Francisco Cal.	Fair.......	97 per cent very cool days.	Very cool nights.....	Very damp.
Reno, Nev.......	Fair	91 per cent cool days.	Very cool nights....	Very dry.
Fresno, Cal......	Fair	99 per cent hot days.	Cool nights..........	Very dry.
New Orleans, La.	Showery..	48 per cent warm days.	Hot nights...........	Very damp.
Chicago, Ill......	Showery..	32 per cent alternately warm and cool days.	Cool nights..........	Damp.
Red Bluff, Cal...	Fair.......	95 per cent warm days.	Alternately warm and cool nights.	Very dry.

That the reader may judge for himself as to the merits or demerits of the method, I give in Table 3 the weather, temperature, and humidity data which governed me in classifying the climates of the 10 cities named in Table 2.

TABLE 3.—*Data underlying the classification of Table 2.*

	Character of summer.	Temperature, summer means.		Humidity, summer means.	
		Maximum.	Minimum.	A. M.	P. M.
		°F.	°F.	Per ct.	Per ct.
Modena, Utah..............	86 per cent fair..........	86	52	42	21
Atlantic City, N. J.........	32 per cent showery.....	76	64	84	87
Phoenix, Ariz...............	87 per cent fair..........	102	74	45	19
Galveston, Tex.............	29 per cent showery.....	88	78	82	75
San Francisco, Cal.........	97 per cent fair..........	65	53	91	76
Reno, Nev...................	91 per cent fair..........	83	50	62	25
Fresno, Cal.................	99 per cent fair..........	96	62	54	16
New Orleans, La...........	48 per cent showery.....	88	75	82	73
Chicago, Ill..................	32 per cent showery.....	77	63	74	69
Red Bluff, Cal..............	95 per cent fair..........	93	64	52	21
Shreveport, La.............	73 per cent fair..........	92	72	42	21

Table 3 presents many interesting features of our summer climates. For instance, on first thought the average reader would probably put Shreveport and Galveston in the same class. Note, however, that while the days are warmer in Shreveport the nights are cooler. The delightful coolness of San Francisco's days and nights are brought out in strong relief, but so is its excessive humidity. While Phoenix and Fresno are practically of a kind as to hot days, yet Fresno's nights are far more pleasant. The New Yorker (going outside the table) who spends his summers in Atlantic City may look for cooler afternoons, but the nights will not seem appreciably cooler, as New York has a mean summer minimum of 65°. The summer in Asheville, N. C., is cool (mean maximum, 82°; minimum, 60°) because it is showery (40 per cent); and, by the way, its dampness is almost as pronounced as that of San Francisco, i. e., 83 per cent. The heat of the day is practically the same in New Orleans and Galveston, but the nights are somewhat cooler in New Orleans. Reno and Denver differ but little as to daytime temperatures, yet Reno's nights are appreciably cooler. It is as warm, as a rule, in St. Louis during the daytime at it is in Modena, but their nights are not at all in the same class, Modena's being something like 17° cooler. Portland, Oreg., and Chicago, though in the same division in regard to maximum temperatures, differ materially at night; Chicago is the warmer place by nearly 10°.

The writer hopes, in conclusion, that this paper may elicit a free and vigorous expression of opinion from climatologists and laymen as to the practicability and adequacy of this method for classifying American summers.

BEACH FOG AND FRACTO-CUMULUS.

Mr. F. D. Young, assistant observer at Portland, Oreg., sends us the following notes of a phenomenon which is not unusual but is not often described:

At Garibaldi Beach, near Tillamook, Oreg., the shore is very straight for a distance of 8 or 10 miles and along this whole stretch its inclination is very slight, so that the area of sand uncovered by the receding tide is great.

On August 15, 1915, a very steady wind was blowing from the north, directly along the beach. There were no clouds in the sky, and while the sun was shining brightly the day was agreeably cool. As the tide receded, it was noticed on looking up the beach that there was a bluish white haze above the wet sand that very nearly obscured objects a mile away. Away from the beach, on the ocean and on the land, the air was still very clear. This haze had the appearance of smoke, and the writer walked up the beach expecting to find the driftwood burning. After a mile walk up the beach, however, it was realized that it was not smoke but light fog. On looking closely the vapor could be distinctly seen rising from the wet beach.

About 11 a. m., when the tide had receded some distance, the haze disappeared and a long row of fracto-cumulus clouds appeared in a narrow strip directly above the beach, stretching out of sight in either direction. They were at a very low altitude, probably about 300 or 400 feet. Except for a few cirro-cumulus clouds on the western horizon, the remainder of the sky was clear and the air was without a suggestion of haze in any direction.

NOTES AT HONOLULU, HAWAII, DURING SOLAR ECLIPSE OF AUGUST 10, 1915.

By WILLIAM W. WYATT, Assistant.

[Dated: Weather Bureau, Honolulu, Hawaii, Aug. 24, 1915.]

The annular eclipse of the sun on August 10, began at 10:36 a. m. and ended at 1:53 p. m., 157° 30′ Meridian Time, as given by the Observatory of the College of Hawaii.

Of the phenomena attending the eclipse the most interesting was the cloud formation, especially the upper clouds, which are seen here only occasionally. At 10 a. m. the only clouds visible were a few of the constantly present cumulus hanging over Mount Tantalus.

The air was very moist and the reduction in temperature resulting from the cutting off of the sunlight was sufficient to cause the formation of the upper clouds. Cirri began to form at 12:05 p. m. and were very thin

and gauzy. While one watched one could see them grow thicker, and at 12:15 p. m. they had changed to cirro-strati. The process of thickening continued as well as the appearance of descending. At 12:25 p. m. they had changed to alto-stratus. The upper clouds became noticeably less at 12:45 p. m. and had entirely disappeared a few minutes before the end of the eclipse. Their movement during the entire observation was from the west and noticeably rapid.

The lower clouds were cumulus, moving rapidly from the east, with the surface wind. They could be seen rapidly whirling when they reached a point over the sea about half a mile west of the station. They seemed to be torn to pieces by the whirling and quickly disappeared.

An arc of about 90° of a solar halo was observed at 12:21 p. m., with colors well defined. It lasted but a short while, disappearing at 12:24 p. m.

The sun at the maximum obscuration appeared to be about two-thirds covered. The moon, shutting off the sunlight, began at the lower right-hand side and ended at the upper left. The electric sunshine recorder gave a record of 20 minutes between 11 and 12 o'clock, the last of which was at 11:24 a. m. It began to record again at 1:27, which was 26 minutes before the end of the eclipse. Although the instrument failed to make a record, the crescent of the sun was too bright almost throughout the duration of the eclipse to allow one to observe it with the naked eye. Little groups of people at street corners, on housetops, and elsewhere were interested observers, using artificial eye aids for the purpose. The eclipse cast fantastic shadows on the sidewalks and streets, foliage and limbs of trees being seen as if in dark relief on the pavement.

At the regular 8 a. m. observation (local time) conditions were not unusual: Temperature, 79°F.; barometer at sea level, 30.01 inches; wind, east, 12 miles; and relative humidity, 66 per cent. Light rain was falling from the cumulus clouds which covered nine-tenths of the sky. At 8:40 a. m. the rain stopped and the sky began to clear slowly.

The wind movement for the 24 hours preceding 12 noon on the day of the eclipse was 362 miles, or 15.1 miles an hour; the movement for the succeeding 24 hours was 237 miles, or 9.9 miles an hour.

The barometer did not show any marked disturbance during the 24 hours of August 10, being between 29.95 and 30 inches until 9 p. m., when it began to rise and reached 30.03 inches at 11 p. m., after which it began to fall slightly.

The thermograph was much more active. Instead of making its usual high record during the middle of the day it rose gradually until 11 a. m., when it registered 82°F., then began to drop. It reached its lowest point at 12:15 p. m., recording 79.5°F., after which it rose slowly until a few minutes after 2 p. m., when it recorded 83.6°F. The shutting off of the sunlight had the same effect on the thermograph as the sudden showers to which this place is subject.

SECTION III—FORECASTS.

FORECASTS AND WARNINGS FOR AUGUST, 1915, WASHINGTON, D. C., DISTRICT.

By H. C. FRANKENFIELD, Professor of Meteorology.

[Dated Sept. 27, 1915.]

GENERAL PRESSURE DISTRIBUTION OVER THE UNITED STATES AND CANADA, INCLUDING THE SANDWICH AND ALEUTIAN ISLANDS, ALASKA, AND THE WESTERN PORTION OF THE MIDDLE ATLANTIC OCEAN.

Pressure was nearly normal throughout the month at Honolulu, with greatest departure occurring during the low-pressure period on the 27th and 28th. However, the lowest barometer reading was only 29.92 inches. About one-third of the reports were missing from the Dutch Harbor station in the Aleutian Islands, but the reports received indicate that pressure was generally above normal, except from the 11th to the 16th, inclusive, when it was quite low. The highest pressure occurred during the first five days of the month and on the 19th and 20th. Over Alaska pressure was generally low throughout the month, except between the 17th and 24th, inclusive, and during much of the month the barometer readings were considerably below normal. The high pressure on the 19th and 20th was equally marked. These marked changes over Alaska did not extend eastward and southward, and over the Canadian northwest pressure did not depart much from the normal throughout the month. Over eastern Canada conditions were somewhat more active, especially with regard to high pressure, but there were no changes of marked character, except in the Hudson Bay region, where a pronounced high area on the 17th was followed by an equally pronounced low area a week later.

The effects of the tropical disturbance of the second decade of the month were limited to the West Gulf States and the lower Ohio Valley. With this single exception barometric conditions throughout the United States do not deserve special mention. Pressure slightly above normal ruled in the West and the extreme Northwest, while in the East and South it was slightly above normal during the first half and slightly below during the second half of the month, and the same conditions prevailed over the western portion of the Middle Atlantic Ocean.

STORM WARNINGS.

The principal storm of the month, the great tropical disturbance of August 10–23, is described in another portion of this REVIEW. With this exception the weather of the month was practically featureless so far as storm warnings are concerned. The disturbance that appeared over central Florida on the morning of the 1st developed considerably during the ensuing 24 hours, and northeast storm warnings were therefore ordered from Fort Monroe to Savannah and southeast warnings at Jacksonville. During the next 24 hours moderate gales occurred along the South Atlantic coast and storm warnings were extended northward to Boston, the storm in the meantime having moved to southern Virginia with somewhat increased intensity. At the same time another disturbance that developed over the Middle West had reached Indiana, and northeast storm warnings were therefore ordered at 10 a. m. of the 3d on Lake Huron, and at 2 p. m. on eastern Lake Superior and northeastern Lake Michigan. Moderate gales occurred over these sections during the day and night of the 3d, and on the morning of the 4th the southern storm was central over southeastern Pennsylvania, while the western one was still over the Upper Lakes with diminishing intensity. As high pressure continued over New England and the Canadian maritime Provinces, the northeast storm warnings were continued from Boston to Sandy Hook and extended northward to Portland, Me. Moderate to fresh gales occurred on the New Jersey and southern New England coast during the 4th, but by the morning of the 5th pressure was rising generally and the warnings were lowered at the expiration of the 24-hour period. There were no other storm warnings during the month, except on the 20th, when the West Indian storm was central over the lower Ohio Valley. This storm had not yet presented any indication of rapid disintegration and northeast storm warnings were therefore ordered for the Lower Lakes, Lake Huron, and the central and southern portions of Lake Michigan. There were, however, no high winds on the Lakes, although in the Ohio Valley and portions of the middle Mississippi Valley moderate gales occurred.

Several small craft warnings were ordered during the month for moderately strong winds that occurred in various localities.

FROST WARNINGS.

On the morning of the 24th high pressure with low temperature covered the Northwest and warnings of possible light frost, if the weather cleared, were issued for upper Michigan. This warning was not verified owing to the unexpected appearance of a low-pressure area to the northward, but as pressure continued high in the Canadian Northwest, the warnings were repeated on the following morning. While the minimum temperatures were quite close to the frost line, no frosts were reported at regular Weather Bureau stations. As pressure was still rising over the Lake region, frost warnings were again issued for upper Michigan and also for northeastern New York, northern Vermont, northern New Hampshire, and northwestern Maine, and on the morning of the 27th light frosts occurred as forecast. They, however, extended into lower Michigan where no warnings had been issued. As conditions had changed but little, further warnings were issued on the morning of the 27th for northern lower Michigan, eastern and southern upper Michigan, the lower Lake region, except Ohio, the interior of eastern New York, western Massachusetts, and northern New England. These warnings were verified from New York eastward, but not to the westward, as a low-pressure area over North Carolina and another in Minnesota caused increased cloudiness with rising temperature.

The Minnesota disturbance was followed by another marked rise in pressure, and on the morning of the 29th

frost warnings were again issued for upper Michigan and northern and western lower Michigan, and the warnings were partially verified. On the 30th frost warnings were issued for eastern upper Michigan, lower Michigan, Indiana, and northern and central Ohio and were fully verified, except over northern Michigan. At this time (31st) high pressure and low temperature prevailed over the Ohio Valley and frost warnings were therefore issued for the eastern and southern portions of West Virginia, but they were apparently not verified.

Chicago District.—Frost warnings were issued for the cranberry marshes of Wisconsin on the 18th, 24th, 25th, 26th, 27th, 29th, and 30th; also, on the 28th, frost being indicated for the night of the 29th–30th, an advisory warning was issued apprising the cranberry growers of that fact, so as to prevent the water being drawn off from the bogs on the 28th. The warnings of the 18th, 26th, 27th, 28th, and 29th were fully verified, while that of the 30th was partially verified.

Warnings of light frost in exposed places of the lowlands of the tobacco region of Wisconsin were issued on the 24th, but cloudiness prevented frost formation. No special warnings were sent to the tobacco region after the 24th, due to the fact that this office was informed on the 25th that tobacco cut within about 10 days of that date would be a total loss, as the crop was immature on account of the unusually cool summer.—*Chas. L. Mitchell, Asst. Forecaster.*

Frost warnings for the several States were issued as follows: 24th—exposed places in northeastern Minnesota; 25th—northern Minnesota and northeastern North Dakota; 26th—eastern North Dakota, north and central Minnesota, and lowlands of Wisconsin; 28th—North Dakota, northwestern Minnesota, extreme northern South Dakota, and northwestern Wyoming.

The warning of the 24th failed of verification, while that of the 25th was fully, and those of the 26th and 28th were partially verified.

The storm warnings in the New Orleans district are covered in the special report on the West Indian storm. No special warnings were issued in the Denver (Colo.), San Francisco (Cal.), and Portland (Oreg.) districts, except in the latter, where "fire wind" forecasts were issued to advantage on the 18th, 19th, 20th, and 21st.

THE TROPICAL STORM OF AUGUST 10, 1915.

By H. C. FRANKENFIELD, Professor of Meteorology.

[Dated: Weather Bureau, Wash., Sept. 25.]

SOME HISTORICAL DATA.

Records of West Indian hurricanes are available, at least as to time and locality of occurrence, as far back as 1493, and from that year to the present 492 storms were noted, an average of little more than one each year. The great storms that reached the United States were, of course, not very numerous, yet they occurred with sufficient, though very irregular, periodicity to warrant the reasonable expectation of one every few years. Severe tropical storms visited Galveston in the years 1834, 1837, 1847, 1854, 1866, 1867, 1875, 1886, 1900, 1909, and 1915, and those of 1900 and 1915 were by far the most violent. The more severe tropical storms of recent years in the United States were:

1. The Atlantic coast storm of August, 1873.
2. The Atlantic coast storm of September, 1874.
3. The Texas storm of September, 1875.
4. The Atlantic coast storm of September, 1876.
5. The Atlantic coast storm of October, 1877.
6. The Atlantic coast storm of September, 1878.
7. The Atlantic coast storm of October, 1878.
8. The Atlantic coast storm of August, 1879.
9. The South Atlantic coast storm of August, 1881.
10. The Gulf and Atlantic coast storm of September, 1882.
11. The Atlantic storm of September, 1883.
12. The South Atlantic coast storm of August, 1885.
13. The Texas coast storm of August, 1886.
14. The Atlantic coast storm of November, 1888.
15. The Atlantic storm of September, 1889.
16. The South Atlantic coast storm of August, 1893.
17. The Gulf storm of October, 1893.
18. The Atlantic coast storm of October, 1894.
19. The Atlantic coast storm of September, 1896.
20. The Porto Rico storm of August, 1899.
21. The Galveston storm of September, 1900.
22. The Gulf storm of August, 1901.
23. The Florida storm of September, 1903.
24. The Gulf storm of September, 1906.
25. The South Atlantic storm of October, 1906.
26. The west Gulf storm of July, 1909.
27. The Gulf storm of September, 1909.
28. The Atlantic storm of October, 1909.
29. The Atlantic storm of October, 1910.
30. The South Atlantic storm of August, 1911.
31. The Gulf storm of August, 1915.

ORIGIN OF TROPICAL STORMS.

The causation of tropical storms is somewhat a matter of conjecture and theory. The subject has been more or less fully discussed by many writers, but nothing has been evolved in very recent years that is in conflict with the theory advanced by Prof. F. H. Bigelow,[1] which is as follows:

> Hurricanes occur in the southeastern parts of the United States and adjacent waters during the season of the year when the cooling of the Northern Hemisphere takes place as the sun retreats toward the Southern Hemisphere. At this season the calm belt of the Tropics and the heated, moist condition of the air in the region known as the doldrums are at their farthest northern limit. The South Atlantic permanent anticyclone, which lies over the subtropical ocean, is in its fullest vigor. Now, superposed upon these states of the lower atmosphere, the colder temperatures of the upper atmosphere, caused by the approaching autumn, on account of the more rapid circulation higher up, overspread the tropic strata near the surface. As the polar air cools first, it flows gradually above the warmer air at the south of it near the ground, and covers it with a circulating sheet of temperature cool or low for the time of year. The effect of all this is to make the atmosphere unstable, that is to say, too warm at the bottom, compared with that above it, to be able to maintain the usual equilibrium. The tendency is, therefore, for the lower air to rise vigorously and burst its way upward by convection, in order that the normal equilibrium may be restored. Of course, this action is favorable to the formation of cyclonic gyrations and the development of severe storms. Hurricanes seem to generate in some such way as this, though our observations are as yet inconclusive on that point, since there is always observed to be a stagnant, warm condition over the ocean at the time the incipient cyclonic action begins. It is to be especially considered that the isotherms in hurricanes do not show any very decided differences in temperature on opposite sides of the center, such as always prevail in the cyclones of the north. There are no counter-flowing currents here, and no source is known from which these can arise in the equatorial region to produce the marked temperature gradients found in cyclones. Furthermore, hurricanes are much more circular in shape and conform more exactly to the pure theory of cyclones as derived from the mathematical analysis.

A very large majority of the hurricanes of which there is record, occurred during the autumn or pre-autumn season, in accordance with the above, but a considerable number occurred in July, and some during the earlier months of the year, even in the winter. These, however, were probably due to some intensification of the usual contributory causation, and were not in conflict with the general idea. Again, the hurricanes of the winter, spring,

[1] Features of Hurricanes, by Prof. F. H. Bigelow. Year Book, Department of Agriculture, 1898.

and early summer are not usually of marked character, although some of the July ones were as violent as those of the autumn.

As to the place of origin of tropical storms, it is probably best to quote again, this time from the late Prof. E. B. Garriott:[2]

Aside from the fact that they commonly emerge from the region of equatorial rains, which lies between the Lesser Antilles and the African coast, little is known regarding the place of origin of West Indian hurricanes. It has seemed allowable in instances to assume that storms which have been encountered by vessels far to the eastward of the Lesser Antilles have subsequently visited the West Indies, but owing to the very meager amount of data which has been received from the tropical ocean such assumptions are not susceptible of definite proof. It is not improbable, however, that some of the West Indian hurricanes originate over the mid-Atlantic tropics and even well over toward the Cape Verde Islands. The latitudinal limits of the region within which these storms originate may be safely represented by the parallels of 8° and 20° north, and it is believed that they have their origin along the line of the southern limit of the northeast trades. As the summer advances the North Atlantic area of high barometer settles southward over the eastern Atlantic, forcing the limit of the trade winds southward, and causing hurricanes to form farther and farther to the westward until October, when they develop or originate over the eastern Caribbean Sea or but a little distance east of the Lesser Antilles.

Later years have added but little of value to our knowledge of the subject. Those who desire detailed information as to hurricanes and their paths are referred to the publications of Profs. Bigelow and Garriott, earlier mentioned, and also to the works of Prof. Oliver L. Fassig[3] of the Weather Bureau, and of Father Benito Viñes.[4]

PATHS OF TROPICAL STORMS.

The paths of tropical storms roughly follow the general atmospheric circulation, from east to west in the Tropics and from west to east in the more northern latitudes. They usually pursue a west to northwest path, recurve, and then move northeastward. Many, of course, do not recurve at all and are dissipated. As to the point of recurving, it appears to be well to again quote from Prof. Garriott:[5]

The recurve of storms in the West Indies and over the Gulf of Mexico is dependent upon general meteorological conditions, and more especially upon the distribution of atmospheric pressure. The anticyclonic or high-pressure area of the North Atlantic Ocean lies northeast of the West Indies, and causes east to northeast winds over the southern part of the ocean and the Caribbean Sea. The storms that develop in the region east of the West Indies, and also those of a more western origin, have a tendency to follow the course of the main equatorial current over the Caribbean Sea. This course is doubtless largely influenced by the general drift of the atmosphere in that region, and, following the anticyclonic circulation of winds, the hurricanes skirt the western quadrants of the Atlantic high area, and, carried by the general drift of the atmosphere, follow paths which recurve north and northeastward near the southeastern coasts of the United States. As a majority of the hurricanes traced followed the course indicated, it may be considered the usual course of West Indian storms when the usual meteorological conditions obtain over the southern and southwestern North Atlantic Ocean and the eastern part of the United States. Some of the more important storms that originate near the West Indies do not recurve to the northward, but move westward over the Gulf of Mexico and dissipate over Mexico or the Southwestern States. In such cases high barometric pressure to the northward apparently prevents a recurve.

According to Prof. Fassig's computations the mean paths for June and July originate between latitude 10° and 15° N., and do not recurve until they reach about latitude 27.5° N. in longitude 86.5° W. (east-central Gulf of Mexico), whereas the mean paths for August, September, and October originate north of latitude 15° and recurve over Florida or the adjacent ocean, the August one on the west coast, the September one over southern Florida, and the October one at a point just touching the extreme southeast coast, but with a movement much more toward the east. It is a fact, however, that some of the most violent storms move as far west as the Texas coast before recurving, notably those of 1900 and 1915, indicating clearly that the probability of recurve and the point of recurving are governed almost entirely by the pressure distribution to the northward.

THE STORM OF AUGUST, 1915.

The meteorological history of this storm was discussed in a special bulletin issued by the Weather Bureau, and the description herewith was copied from that bulletin. Figures 1–12 (XLIII, 92–103), at the back of this REVIEW, show the paths of the storms of 1900 and 1915, and also the pressure conditions that prevailed during the passage of the storm of 1915. Charts for 8 a. m. only, are shown for the period from August 10 to 14, inclusive, while both the 8 a. m. and 8 p. m. charts are reproduced for the period from 8 a. m. August 15 to 8 p. m. August 17, inclusive.

When the storm passed inland from the Texas coast, observations became available giving for the first time the barometric pressure at the approximate center and closely adjacent points. The lowest pressure at Houston, Tex., was 28.20 inches, and it is fair to assume that the pressure at the center of the storm throughout its journey across the Gulf of Mexico was at least as low as 28.5 inches. Isobars in dotted lines have therefore been drawn on the maps on this basis, showing the passage of the storm over the Gulf of Mexico, although only a few scattered reports were available, and they for points at a distance from the center.

This storm proved to be somewhat of an exception to the rule for the pressure conditions that prevailed for a week or two previous were not such as to indicate any probability of the development of a tropical disturbance. It is true that pressure had been quite high over much of the United States and the North Atlantic Ocean during July, and relatively low over the eastern Atlantic as indicated by reports from the Azores Islands, but during the first decade of August these conditions were reversed over the Atlantic States and the western portion of the Atlantic Ocean, although not decidedly so over the ocean where the pressure was still slightly above normal. Thus, as has been said, there was nothing to indicate that conditions were favorable for the formation of a tropical storm, nor, should one form, was there anything pronounced to indicate its direction of progression, whether northwestward to the south Atlantic coast or westward to the Gulf of Mexico, the slight preponderance of pressure over the North Atlantic not having been sufficient to enable this fact to be determined.

The storm was first observed on the morning of August 10 between the Windward Islands of Barbados and Dominica, and at 9:45 a. m. on that date the first warning notice of the storm was sent to West Indian stations. At 2 p. m. similar information was sent to all Atlantic and Gulf stations of the Weather Bureau, and in addition the information was disseminated by the radio station at Arlington, Va. Nothing more definite from the scene of trouble was received during the day, except a special report at 4 p. m. from Roseau, Dominica, which showed a barometer reading of 29.46 inches, with light air from the northwest. On the morning of August 11 the disturbance was apparently near and south of the

[2] West Indian Hurricanes. Washington, 1900. (Weather Bureau Bulletin H.)
[3] Hurricanes of the West Indies. Bulletin X, Weather Bureau, 1913.
[4] Cyclonic Circulation and the Translatory Movement of West Indian Hurricanes. Washington, 1898. (Weather Bureau No. 168.)
[5] Summary of International Meteorological Observations. Washington, 1893. (Weather Bureau Bulletin A.)

island of St. Croix, at about latitude 16° N., longitude 66° W. At this time the barometer at San Juan, P. R., read 29.60 inches with a gale of 60 miles an hour from the northeast, indicating a much lower pressure to the southward, and pressure was falling more rapidly to the westward, as indicated by the observations at Santo Domingo, Santo Domingo, and Port au Prince, Haiti. The following information was then distributed over the West Indies generally and to Atlantic and Gulf ports:

Severe tropical disturbance at 8 a. m. apparently central near island of St. Croix, moving west-northwest 18 or 20 miles and hour. Will probably cross Santo Domingo and Haiti, reaching southeastern Cuba about Thursday night or Friday (Aug. 12–13).

On the morning of the 12th the storm was central a short distance south of Haiti at about latitude 17°, longitude 73°. The barometer reading at Port au Prince was 29.60 inches and the highest wind velocity was 32 miles an hour from the east. However, reports of damage over the southern portion of the Republic indicated that a severe gale must have occurred there with much lower pressure. On the same morning the barometer reading at Kingston, Jamaica, was 29.68 inches, and northerly gales were reported east of the island. The wind at Kingston was then light northwest, and pressure was also falling to the westward and northwestward, Songo (near Santiago), Cuba, reporting a barometer reading of 29.80 inches, a fall of 0.16 inch in 24 hours, with light northeast winds. Warnings were again issued at about 10 a. m. to the effect that the tropical storm was apparently central near southwest Haiti, moving a little north of west, and that it would probably reach southeast Cuba that (Thursday) night. Observations taken at 12 noon of the 12th indicated that the storm center was near the east coast of Jamaica, moving a little north of west, and advices were issued accordingly to all Gulf and Atlantic ports, and also to West Indian points that were likely to be affected.

During the night of the 12–13th the storm center passed north of the Island of Jamaica, and at 8 a. m. of the 13th a whole southeast gale was blowing at Kingston. Northeast storm warnings were then ordered at Key West and Miami, Fla., and advices issued stated that the storm would probably reach western Cuba Friday night and Saturday, and that hurricane warnings might be necessary later. All interested, and especially shipping, were advised at the same time to take every precaution necessary for safety. At this time the barometer reading at Key West was 29.92 inches, and the wind velocity 16 miles an hour from the east. Special observations received during Friday, the 13th, indicated that the storm was moving as forecast, and accordingly at 5 p. m., the warnings at Key West and Miami were changed to hurricane, and hurricane warnings were also ordered on the southwest coast of Florida as far north as Boca Grande. The warnings stated that easterly winds would increase that night possibly reaching hurricane force Saturday. All shipping and others interested were warned to take every precaution possible and vessels in port were warned to remain there.

On the morning of the 14th the storm was apparently central near the Isle of Pines, Cuba, with undiminished intensity and moving in a direction a little north of west. Advisory warnings on that morning, which were sent to all interested, stated that the storm would probably pass into the Gulf of Mexico that (Saturday) night. During Friday night the maximum wind velocity at Habana was 56 miles an hour from the east. It was apparent that during Sunday the storm center would probably reach the north-central Gulf of Mexico, and Gulf shipping was advised to take every precaution. At 5 p. m., Saturday, the 14th, hurricane warnings were continued from Key West to Boca Grande, but were lowered at Miami, as it was apparent that there was no longer any danger of winds of storm force at that station. As the next day would be Sunday, the officials in charge at Weather Bureau stations were ordered to make arrangements for Sunday telegraph service in their districts in order that any warnings that might be necessary could be received and distributed properly. On the morning of the 15th the storm was apparently central in the south-central Gulf of Mexico moving in a more northwesterly direction than before. The barometer at all Gulf stations was falling, and northeast storm warnings were therefore ordered on the Gulf coast from Apalachicola, Fla., to New Orleans, La. All Gulf stations, both regular and display stations, were notified accordingly, with warnings that all interested should take every precaution for safety, and that all vessels should remain in port. The special observations received during Sunday, the 15th, indicated the necessity of hurricane warnings on the west coast, and at 5 p. m., the northeast warning at New Orleans was changed to hurricane, and hurricane warnings were also ordered at all display stations westward as far as Brownsville, Tex. A radio report taken at 2 p. m. on the S. S. *Antilles*, at latitude 27°, longitude 86°, showed a barometer reading of 29.54 inches with wind velocity of 74 miles an hour from the east, and another radio report taken at 8 p. m. on the same date, at about latitude 26.5°, longitude 87.5°, showed a barometer of 29.48 inches, with wind velocity of 64 miles an hour from the east. On Monday morning, August 16, the storm center was apparently approaching the east Texas coast and the warnings from Mobile to Apalachicola were changed from northeast to southeast. At this time the barometer at Galveston read 29.62 inches with maximum wind velocity of 34 miles an hour from the northeast. The conditions continued to intensify, and by noon the barometer at Galveston had fallen to 29.48 inches with maximum wind velocity of 56 miles an hour from the northeast. The tide was rising slowly and the sea was excessively rough. At 5 p. m. the hurricane warnings were ordered continued from Sabine, Tex., to Brownsville, Tex., and the warnings at New Orleans and Morgan City, La., changed from hurricane to storm southeast, as it was apparent that the winds at these places could no longer increase, the maximum wind velocity at Burrwood, La., at the mouth of the Mississippi River, being only 48 miles an hour from the east. At 8 p. m. Monday, August 16, the barometer at Galveston read 29.10 inches with maximum wind velocity of 72 miles an hour from the northeast, and heavy rain was falling. The storm passed into the interior during the night of August 16–17, and at 2:45 a. m. Tuesday, August 17, the barometer at Galveston read 28.63 inches, with maximum wind velocity of 93 miles an hour from the east at 2:37 a. m. At 5:30 a. m. of the 17th the barometer at Houston read 28.20 inches, with a maximum wind velocity of 80 miles an hour (estimated) from the northeast.

Hourly barometer readings were also made by E. F. Roeller at Velasco, Tex., about 40 miles southwest of Galveston and about 14 miles southwest of San Luis Pass, where the storm center first reached the coast. The curve plotted from his readings forms figure 13. It shows that the lowest pressure, 28.06 inches, occurred at 1 a. m. August 17, at which time the wind backed from

north to northwest. The table following gives the pressure and wind direction at frequent intervals during the height of the storm at Velasco:

TABLE 1.—*Barometer readings by E. F. Roeller at Velasco, Tex., during August 16 and 17, 1915.*

[Correction of +0.08 inch to be applied.]

Date and hour. [90th mer. time.]	Barometer reading.	Wind.	Date and hour. [90th mer. time.]	Barometer reading.	Wind.
Aug. 16, 1915.	*Inches.*		*Aug. 16, 1915*—Contd.	*Inches.*	
1:20 p. m.	29.40	ne.	10:00 p. m.	28.66	n.
2:00 p. m.	29.38	ne.	10:20 p. m.	28.60	n.
2:20 p. m.	29.36	ne.	10:30 p. m.	28.56	n.
2:45 p. m.	29.34	ne.	10:50 p. m.	28.50	n.
3:15 p. m.	29.30	ne.	11:10 p. m.	28.48	n.
3:30 p. m.	29.28	ne.	11:30 p. m.	28.40	n.
3:45 p. m.	29.24	ne.	11:45 p. m.	28.34	n.
4:15 p. m.	29.22	ne.	12:00 p. m.	28.28	n.
4:30 p. m.	29.20	n.	12:15 a. m.	28.24	n.
5:00 p. m.	29.18	n.	12:25 a. m.	28.18	n.
5:30 p. m.	29.14	n.	1:00 a. m.	28.14	nw.
6:10 p. m.	29.12	n.	1:30 a. m.	28.18	nw.
6:40 p. m.	29.08	n.	1:50 a. m.	28.30	nw.
7:00 p. m.	29.06	n.	2:15 a. m.	28.40	nw.
7:20 p. m.	29.02	n.	2:30 a. m.	28.45	w.
7:45 p. m.	28.98	n.	2:45 a. m.	28.50	w.
8:10 p. m.	28.94	n.	3:15 a. m.	28.60	w.
8:50 p. m.	28.90	n.	3:40 a. m.	28.70	w.
9:15 p. m.	28.82	n.	7:15 a. m.	29.20	sw.
9:25 p. m.	28.80	n.	12:40 p. m.	29.40	sw.
9:40 p. m.	28.74	n.			

This reading of 28.06 inches was not by any means unprecedented, as numerous readings below 28 inches have been recorded during severe storms in different parts of the world. During more recent years probably the lowest recorded pressure was 27.24 inches. This observation was taken on the schooner *Ponape*, lying at anchor at Wlea, West Caroline Islands, at 10 a. m. March 29, 1907, and was noted by Algué in the Monthly Bulletin of the Philippine Weather Bureau for March, 1907.

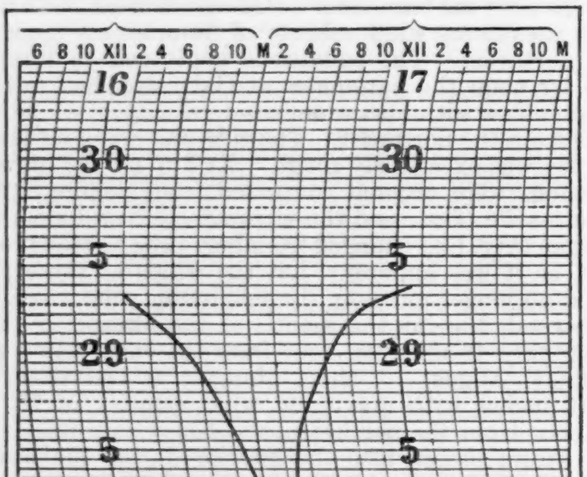

FIG. 13.—Plot of corrected aneroid readings (inches) by E. F. Roeller at Velasco, Tex. August 16-17, 1915.

At 8 a. m. Tuesday, August 17, the barometer at Galveston read 29.12 inches, with the wind blowing 52 miles an hour from the northeast, while at Houston the reading was 28.72 inches, with a wind of 80 miles an hour (estimated) from the southeast. Torrential rains had fallen at both places and were extending into the interior of east Texas. The storm then recurved to the northward, with high winds over the interior of east Texas, reaching a maximum of 60 miles an hour from the north at San Antonio during the day. There was no occasion for further warnings, and those that were still displayed were allowed to expire at 5 p. m. Tuesday, August 17. On the morning of August 18 the storm was central over the northern portion of east Texas, with a barometer reading of 29.50 inches at Fort Worth and Dallas, with northeast gales of 44 to 48 miles an hour and with heavy rains. Warnings of high winds for the interior of east Texas had

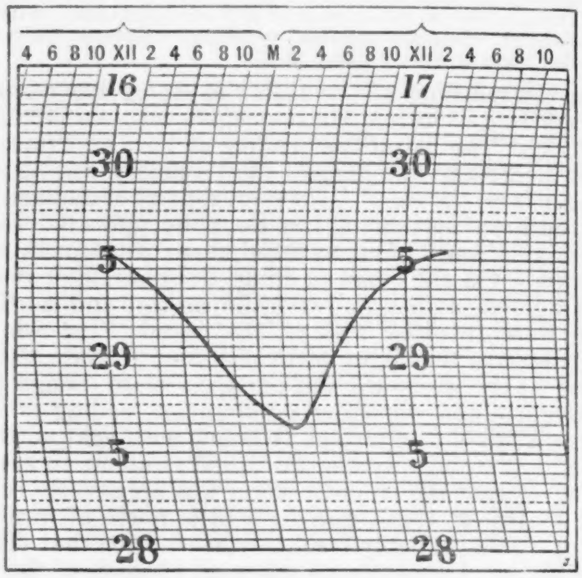

FIG. 14.—Barogram (inches) at Galveston, Tex., noon August 16 to 3 p. m. August 17, 1915.

been issued on the afternoon of the 17th. During the next 24 hours the storm moved very slowly to extreme northeast Texas with somewhat diminished intensity, but with heavy rains continuing in that vicinity and extending into Arkansas. The storm was now moving northeastward, and on the morning of the 20th was central over southeast Missouri with somewhat increased intensity, and heavy rains had fallen in southern and eastern Missouri, the lower Ohio Valley, and west Tennessee, and northeasterly gales prevailed at St. Louis. During the next 24 hours the storm moved slowly to southern Indiana, again with diminishing intensity, but with general rains and some high winds to the southeastward. It then continued its northeastward movement with steadily diminishing intensity, but with general and, in many places, heavy rains, and on the morning of August 24 was passing out into the Gulf of St. Lawrence, with a barometer reading of 29.80 inches at Father Point.

The hourly barometric pressures at Galveston and Houston during the passage of the storm near those stations are shown in the barograms, figures 14 and 15. It will be seen that at Galveston the pressure fall from noon to 6 p. m. on Monday, August 16, was uniform at the rate of 0.06 inch an hour. From 6 p. m. to 10 p. m. the fall was a little more rapid, ranging from 0.08 to 0.12 inch an hour, and the pressure fell below 29 inches for the first time shortly after 8 p. m. From 10 p. m., when the reduced barometer read 28.82 inches, until 2:45 a. m., August 17, at which time the lowest reading of 28.63 inches was recorded, the rate of fall was less than before, averaging a little less than 0.04 inch an hour. From 2:45 a. m. until 9 a. m., August 17, there was a recovery at a much more rapid rate, about 0.11 inch an hour, followed by a much slower rate of rise thereafter.

At Houston the barometer fell at the rate of about 0.04 inch an hour from noon until 8 p. m., August 16, and much more rapidly thereafter, falling below 29 inches at about 12:30 a. m., August 17, about four and one-half hours later than at Galveston. The lowest reading of 28.20 inches, or 0.43 inch lower than at Galveston, was reached at 5:25 a. m., August 17, two hours and forty minutes later than at Galveston. From 8 p. m., August 16, to 5:25 a. m., August 17, the total fall in pressure was 1.18 inches, an average of about 0.125 inch an hour. From 3 a. m. to 5 a. m., August 17, the fall was 0.47 inch, an average of 0.235 inch an hour, while the greatest fall during a single hour was 0.30 inch from 4 a. m. to 5 a. m., August 17. At Galveston the greatest fall in any one hour, 9 p. m. to 10 p. m., August 16, was only 0.12 inch. These figures show that the actual storm center passed much closer to Houston than to Galveston, and, according to the wind directions (NE., E., SE., and S.), a little to the southward and westward of both stations.

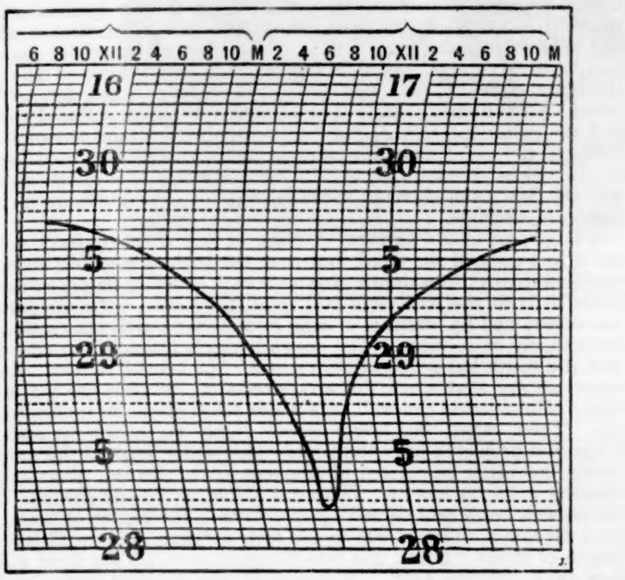

Fig. 15.—Barogram (inches) at Houston, Tex., 8 a. m. August 16 to 12 p. m. August 17, 1915.

As nearly as can be determined the storm center reached the coast of Texas near San Luis Pass, at the end of West Bay, about 26 miles southwest of Galveston, at about 1 a. m., September 17, shortly after which its slow recurve to the northward and northeastward began. The extreme western point of the path was reached between 2:20 and 2:40 a. m., very near and presumably a little to the westward of Sandy Point, Tex. It was next definitely located at about 4:50 a. m. southwest of and very close to Houston, Tex., with a movement slightly east of north.

These deductions are based upon special reports received, mainly, after the passage of the storm, and the center is assumed to have been where the lull, or "calm," that accompanies the shift in wind direction occurred as the storm center passed. At a point about 5 miles northeast of Sandy Point the calm lasted from 2:20 until 2:40 a. m. The time consumed by the storm center in traveling from the coast to Houston, a distance of about 60 miles along the curved path, was very nearly four hours, making the average rate of progression 15 miles an hour. As the calm near Sandy Point lasted about twenty minutes, or one-third of an hour, it may safely be assumed that the diameter of the storm center was one-third of 15, or 5 miles. Some confirmation of this is found in the official report from Houston in which was stated the fact that in Houston the broken and uprooted trees pointed toward the southwest, while 6 miles southwest of Houston they pointed to the north and northward, indicating violent winds in opposite directions within a distance of 6 miles, from which it may be inferred that the storm center could not have been more than 6 miles in diameter.

The storm center evidently passed over Cape San Antonio, Cuba, about 2:30 p. m. August 14, as at that time a calm prevailed, continuing with heat and mist for about one-half hour. The lowest barometer at the Isle of Pines, Cuba, occurred at 3 a. m. August 14, so that the rate of travel of the storm center between that place and Cape San Antonio was about 13 miles an hour. As it occupied one-half hour in passing over Cape San Antonio, the diameter of the center was apparently about 6¼ miles, a very close agreement with the results obtained between San Luis Pass and Houston, Tex.

The following extract regarding the conditions prevailing over the Gulf of Mexico was made from the report of Mr. W. P. Stewart, official in charge of the local office of the Weather Bureau at Galveston:

The recording tide gages of the United States Engineers at Fort Point and of the United States Coast Survey on the wharf at Twentieth Street were carried away by the storm together with their records. There is, therefore, no official record of the tide. A measurement by the United States Engineers at Twentieth and Strand makes the highest point reached 11.965 feet above mean low tide. It appears to be the universal opinion that the water was somewhat higher than in 1900. At 2119 Post office, the highest water in both storms is chiseled on the wall and the record of the recent storm is 3.5 inches higher than that of 1900.[6]

At its highest the water in the retail business district was approximately 5 feet above the street level, the streets being about 6.5 feet above mean low tide. At the American National Insurance Co.'s building it was 5 feet 6.5 inches; at 2110 Avenue E, 4 feet 9 inches; at Tussup Grocery Co.'s store, Twenty-second and Post office, 4 feet 11.5 inches; at Twenty-second and Mechanic, 5 feet 2 inches; at Union Depot, 6 feet. In that part of the town where grade has been raised it was of course not so deep. At Twenty-second and Q it was 2 feet 7 inches; at the county courthouse, 4 feet 11 inches above the street level at the curb.

During the morning of August 15, there was a light southeast swell on the Gulf coming in against a light northeasterly wind. The tide was slightly above normal and it was noticed that it did not fall when it should have done so. During the afternoon it rose slowly and the swells noticeably increased. During the early hours of the 16th the tide rose about 0.3 foot an hour and by daybreak the sea was very rough. At 6:30 a. m. the tide was 4.1 feet and about stationary, but it rose slowly after that time and the sea became increasingly rough. During the afternoon of the 16th and for 36 hours thereafter it was excessively rough. The water began to back in from sewers on down-town streets about noon. At first it rose very slowly and it was 6 p. m. before the streets in the business section were all covered. After that time it rose more rapidly and by 9 p. m. the water was 3 feet deep at Twenty-third and Post office. During the late afternoon the street-car and electric-light services suspended operations and during the early part of the night the gas and water services failed. The tide was highest about the climax of the storm, a little before 3 a. m., August 17. At daybreak it had subsided about 2 feet and the water was again 3 feet deep on the street at Twenty-third and Post office. The tide fell slowly and there was water on some streets until the morning of the 18th.

A curious, although entirely natural, sequence of the storm was the high temperature that prevailed along the southern coast of Texas, beginning with August 15 when the winds first shifted to landward, the fall in temper-

[6] While the water was 3.5 inches higher at the post office in Galveston than in 1900, the highest tide of 11.965 feet does not appear to have been as high as that of the storm of 1900, assuming that the statements of Dr. I. M. Cline regarding the latter are correct. Dr. Cline said (Monthly Weather Review, Sept. 1900, 28: 373):

"* * * The water had now reached a stage 10 feet above the ground at Rosenberg Avenue (Twenty-fifth Street) and Q Street, where my residence stood. The ground was 5.2 feet elevation, which made the tide 15.2 feet. The tide rose the next hour, between 7:30 and 8:30 p. m., nearly 5 feet additional, making a total tide in that locality of about 20 feet. These observations were carefully taken and represent to within a few tenths of a foot the true conditions. Other personal observations in my vicinity confirm these estimates. The tide, however, on the bay or north side of the city did not obtain a height of more than 15 feet. It is possible that there was 5 feet of backwater on the Gulf side as a result of débris accumulating 4 to 6 blocks inland."

ature that usually follows the passage of a storm center over or near a given locality having been entirely absent. In this instance the winds blowing from a warm land area brought with them the high temperatures that prevailed over the interior districts, and the condition persisted until the wind again blew from the water surface to the southeastward. The following data show the conditions at Corpus Christi and Brownsville, Tex., from August 15 to 20, inclusive:

Date.	Maximum temperature during day.		Wind direction at 8 p. m.	
	Corpus Christi.	Brownsville.	Corpus Christi.	Brownsville.
	°F.	°F.		
Aug. 15	91	92	ne.	n.
16	94	97	nw.	nw.
17	97	a 104	nw.	s.
18	a 100	a 104	b se.	se.
19	98	100	s.	s.
20	90	99	se.	s.

a Highest temperatures of record. b Had been south during day.

CASUALTIES.

The casualties resulting from the storm were of minor character east of Santo Domingo and Haiti and were confined to small shipping. At Fort de France, Martinique, the docks were flooded and merchandise destroyed, while at some of the other islands of the Lesser Antilles there was some damage to small shipping. Over the southwestern portion of Haiti real disaster to crops, etc., was reported, but, so far as is known, without loss of life. Over the Island of Jamaica heavy gales were reported, and the banana crop was said to have been damaged to the extent of several millions of dollars. There were no serious disasters to shipping in the Caribbean Sea reported, and to this fortunate condition the warnings of the Weather Bureau doubtless contributed in great measure.

Over extreme western Cuba, which was in the direct path of the storm, the damage was much more serious, and at Cape San Antonio, on the extreme western end of the island, not a house was left standing. The radio station, the steel tower, and the lighthouse were blown down, and the entire meteorological equipment of the Weather Bureau destroyed. Fourteen lives were lost. The schooner *Roncador* was totally wrecked, but without loss of life, and the schooner *Explorer* was dismantled.

There were no serious disasters in the east Gulf of Mexico, although several disabled vessels came into or were brought into Key West. There was only a moderate gale at Key West, but at Sand Key, 8 miles to the southwestward, there was a 60-mile southeast gale.

The greatest marine disaster was the loss on August 13, probably in the Yucatan Channel, of the American steamship *Marowijne*, of the United Fruit Co., from Belize, British Honduras. Notwithstanding the fact that the steamer was equipped with radio apparatus nothing was heard from her and she must have been lost, together with her passengers and crew, numbering in all 96 persons. The vessel was valued at $400,000.

The schooner *Lydia M. Deering*, from Sabine, Tex., for Boston, was lost several miles south of Mobile, and the captain and two members of the crew perished. The schooner *Dora Allison*, from Progreso, Mexico, for Mobile, was wrecked in the Gulf, but her crew was saved. The fishing smack *Nettie Franklin*, of Pensacola, was wrecked in the northwest Gulf and two of her crew were lost.

The losses on the Louisiana and Texas coasts and in the interior of east Texas were such as might have been expected from a great storm.

Over southern Louisiana there was no loss of life, while the property loss probably did not exceed $1,000,000. It was confined mainly to the rice crop and to live stock in the marshes.

The greatest loss of life and property occurred in the vicinity of Galveston, and from thence northward and westward for a considerable distance. The total loss of life was 275, to which the city of Galveston contributed 11; Galveston Island, 42; and the dredges *Houston* and *San Bernard* and the tug *Helen Henderson*, 69. One hundred and two persons were reported as missing, but it is probable that many of these were later accounted for. We quote again from the report of Mr. Stewart:

Of the damage resulting from the direct force of the wind probably the sinking, wrecking, or grounding of vessels of all sizes caused the greatest monetary loss. There are still (August 27) 11 large vessels aground in this immediate vicinity, and several hundred vessels of all sizes were wrecked on the east Texas and west Louisiana coasts. In addition to the wrecking of vessels and the destruction of wharves and sheds along the harbor front, there was an enormous amount of comparatively minor damage due to the direct force of the wind. Windows were broken, and trees, outbuildings, and fences blown down. Of the ornamental, or shade trees, the oaks suffered the most and the palms the least. The leaves on all deciduous trees are withered and dry since the storm, and are falling. The loss from breakage of plate-glass windows in the business district was considerable, as was the loss from damage to roofs, windows, and chimneys in the residence districts.

A large part of the property damage in this storm resulted, not from the direct force of the wind, but from the high tide which flooded the business district to a depth of from 5 to 6 feet and damaged stocks of goods in both the wholesale and retail districts. Great property loss was occasioned by washing of sand from under buildings, causing their overturning or collapse. The seawall which protects the city on the east and south has a height above mean low tide of 17 feet. Reliable observers say that when the waves receded, leaving the sea momentarily calm outside the wall, the water stood about 20 inches from the top. Then, when the larger waves came, an enormous amount of water was projected over the wall. This water washed the sand from under the brick pavement of the seawall boulevard, practically destroying it for 20 blocks. The sand filling or "made ground" inside the seawall boulevard sloped upward toward the center of town. This sand fill had a width of 300 to 400 feet, a depth of 17 to 23 feet and a length of about 2 miles, and was designed to cause the flood waters to flow back into the Gulf. However, it was covered with soil or sod only in a few small patches and wherever not so protected it was washed by the incoming waters back into the town and from under the numerous dwellings that covered it. In this way approximately 200 residences were undermined and more or less seriously damaged. Some were entirely destroyed and nearly all were rendered unfit for habitation. Isolated cases of undermining of houses also occurred in several sections remote from the Gulf front. The sand washed away from near the beach was left farther inland. Some of the street pavements and most of the lawns in the southeastern part of town were covered with sand to a depth of from 2 to 5 feet. About six blocks of single track street railway was undermined and destroyed.

At Fort Crockett the damage is estimated at over half a million dollars. The sand-protected forts were nearly demolished and the sand filling of the military reservation was badly washed. The loss of military equipment was also considerable.

Of the 250 homes on Galveston Island outside the protection of the seawall probably not over 10 per cent are left standing. That there were not more fatalities in that section was due solely to the warnings of the Weather Bureau.

Serious loss resulted from several fires that broke out during the night of the 16th-17th. Along the Gulf front all the structures outside the seawall were destroyed by the storm. The causeway that connected Galveston Island with the mainland was badly damaged. The central part of the structure which consisted of concrete arches did not suffer severely, nor were the dirt and oyster shell approaches at either end seriously damaged, but those portions connecting the central arched section with the shore on either side—each nearly a mile in length—were demolished down to the solid concrete structure that stands slightly above mean tide. It has been estimated that the cost of repairing or reconstructing the causeway will be approximately $500,000. The practical destruction of the causeway was accompanied by the loss of portions of the water main which brought the city water supply from artesian wells at Alta Loma. There was no city water

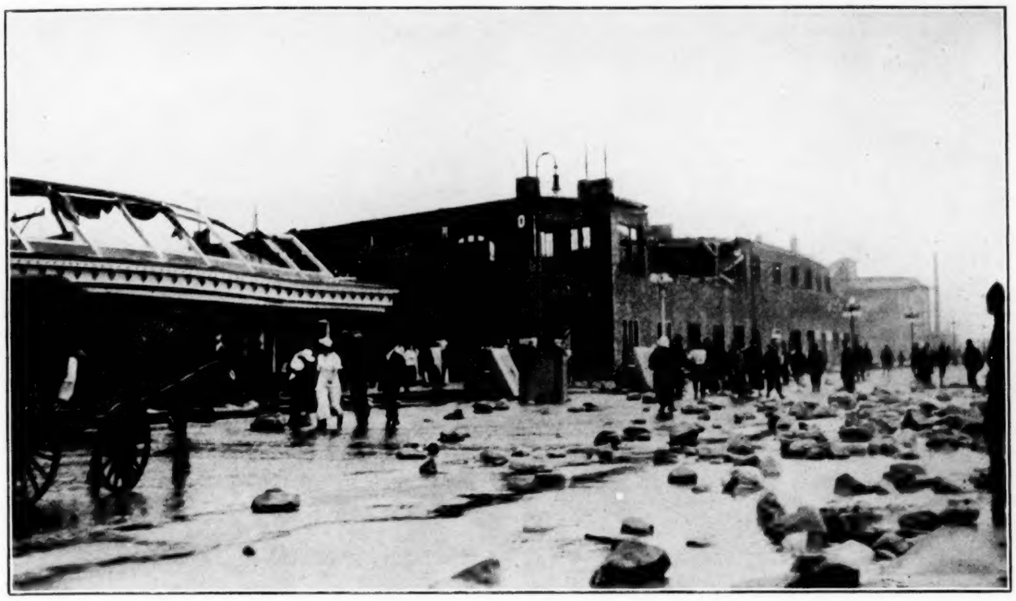

FIG. 16.—Galveston hurricane of August 16-17, 1915. Wrecked Casino and Columbo Café at head of Twenty-third street. Note three granite blocks, each weighing 20 tons, driven across the street from the balustrade of the sea wall by force of waves.

FIG. 17.—Galveston hurricane of August 16-17, 1915. North end of the causeway looking toward Virginia Point Railroad, showing the demolished embankment fill; on the right is the dredge *Houston* thrown upon the causeway.

FIG. 18.—Galveston hurricane of August 16-17, 1915. View of the break in the embankment fill portion of the causeway, with wrecked interurban cars in middle ground. The arched-bridge portion of the causeway, 1,700 feet, remains standing.

FIG. 19.—Interurban track at Virginia Point, looking north. The track and overhead wires were destroyed for a distance of about 3 miles from this point.

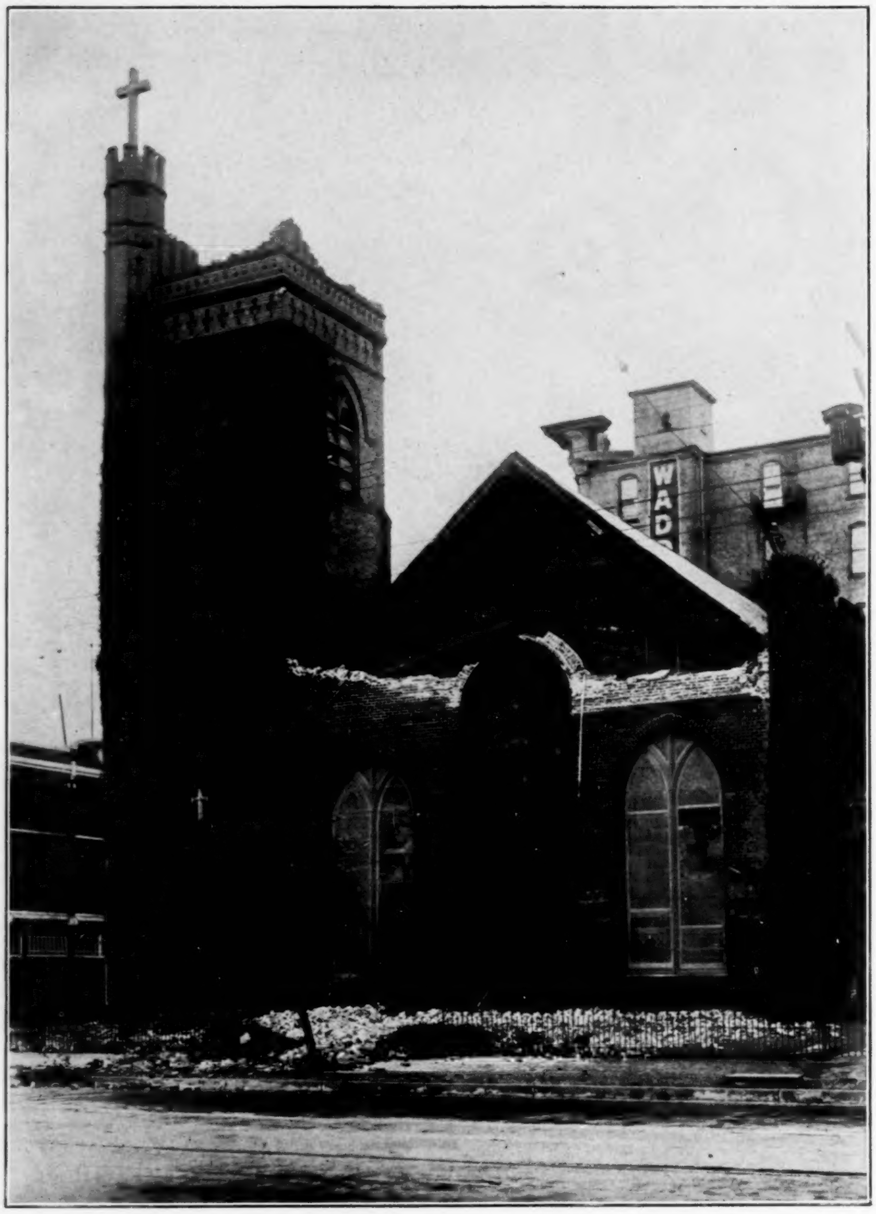

FIG. 20.—Damage to First Christ Church, Houston, Tex., August 16-17, 1915. (Howerton, photographer.)

FIG. 21.—Damage to the Airdome, Houston, Tex., August 16-17, 1915. (Howerton, photographer.)

from the night of the 16th until the morning of the 26th of August. There was little actual suffering on that account, however, as water for cooking and drinking purposes was obtained from cisterns and several artesian wells in the city.

Post-office inspectors report the destruction of the post offices at Chocolate Bayou, Glen, Kemah, Lynchburg, Quintana, Tomball, Wallisville, and Winfree, Tex., with all contents.

The greater portion of the Marconi wireless station fell across and wrecked the building in which the station was located. The only telegraph service in or out of Galveston from the evening of the 16th of August until the morning of the 21st was by radio from the U. S. Army transport *Buford*.

It has been estimated that the damage from this storm to crops, buildings, railroads, shipping, live stock, and other property will aggregate close to $50,000,000, but these figures are probably much too large. Of the total amount approximately $6,000,000 occurred at Galveston.

In the city of Houston the damage amounted to about $1,000,000, mainly to buildings, railroads, telegraph and telephone lines, and nearly every building shared in the damage. Crops in fully one-half the State of Texas suffered severely. Nearly all open cotton was blown away, and much cotton, late corn and rice was flattened by the wind and rain.

Beyond the State of Texas there was also considerable damage by high winds as far as the lower Ohio Valley, particularly over eastern Missouri, but much greater damage was caused by the severe floods resulting from the torrential rains that extended from Texas northeastward to New York. These floods seriously injured the crops in many localities, while in many others where there were no floods, the heavy rains beat down the standing crops

COMPARISON WITH THE STORM OF 1900.

Figure 1 (XLIII–92) shows the paths of the storms of 1900 and 1915. An inspection of these paths discloses the fact that the total time occupied from the first to the last appearance of both storms within the field of observation was exactly 14 days, and that the storm of 1900 moved with a slower velocity of progression before reaching its recurve than after, whereas in the storm of 1915 the reverse was true. The two paths are very similar in many respects, although that of 1915 lay a little to the southward of that of 1900 until the St. Lawrence Valley was reached. In previous published reports on the storm of 1900 the storm path shows a strong deflection toward the southwest Florida coast, but reports received from vessels and other sources after those publications indicated the fact that this deflection to the right was not so strong as has been supposed, and the track as here charted is thought to represent more nearly the true conditions. It was carefully plotted from all available observations. As to the comparative intensities of the two storms, it is perhaps idle to speculate. The wind velocities were not greatly different, and the effects of the two storms were much the same, except as modified by artificial conditions in the vicinity of Galveston. The barometer reading of 28.48 inches at Galveston in 1900 was 0.15 inch lower than the lowest reading recorded in 1915, whereas the lowest reading of 28.20 inches at Houston in 1915 was 0.28 inch lower than the lowest barometer reported in Galveston in 1900. Unfortunately there are no records from Houston for the year 1900, and a precise comparison can not be made.

THE WORK OF THE WEATHER BUREAU IN CONNECTION WITH THE STORM.

If one may judge from press reports and letters received at the Weather Bureau, the warnings issued were the most complete and successful ever issued by the bureau for a tropical storm. Granting this to be true, it must not be assumed that the thoroughness and efficacy of the warnings were alone due to the work of any particular individual. In very large measure the success in forecasting the path and rate of the movement of the storm was rendered possible by the splendid radio service which has become a valuable adjunct of Weather Bureau forecast work since the last severe tropical storm. While it is true that no reports were received from the immediate vicinity of the storm center, probably because the warnings kept the vessels away, those that were received after the storm passed over extreme western Cuba were sufficiently close to the eastward to afford extremely valuable assistance to the forecaster, while the almost total absence of important marine disasters bears abundant testimony to the efficiency of the warning service by means of the radio distribution. There were no useless warnings. The storm did not reach any locality that had not previously had ample warning, and no warnings were issued for any locality that the storm did not reach.

However, the splendid efficiency of the radio service can not and does not detract from the equally efficient work performed by the Weather Bureau stations along the West Indian and Gulf coasts. The distribution of the warnings was as widespread and complete as human energy could make them, and this service undoubtedly saved many lives and a considerable amount of property. Along the Louisiana coast the cordial and effective cooperation of the telegraph and telephone services and of private individuals enabled the official in charge of the local office of the Weather Bureau at New Orleans to make a wonderful distribution of the warnings, while the official in charge at Galveston and the storm warning displayman at Seabrook, Tex., by supplementing the official warnings by personal service to individuals saved many hundreds of lives. It was fortunate also for all concerned that during the first four days of the storm its center was sufficiently close to the stations of observation to enable the forecaster to indicate its velocity of movement with much greater precision than would have been possible had the storm center been at a considerable distance from land. This is an additional reason for the establishment and operation of many more stations of observation in West Indian waters, especially in the vicinity of Panama, if the Weather Bureau is to be able in the future to forecast the approach, progression, and intensity of West Indian hurricanes for the benefit of the commerce and the military establishment of the United States. This same thought should also be extended so as to comprise a more enlarged radio service in West Indian waters. The radio service now conducted by the Weather Bureau in cooperation with the Navy Department, and commercial organizations is extremely effective and valuable, but it is confined entirely to the waters of the western Atlantic, the western Caribbean, and the Gulf of Mexico. Reports are rarely received from the eastern Caribbean, but with the extension of the commercial activities of the United States in the days to come it is to be hoped that this field will be covered as carefully and as fully as are the adjacent waters.

It is a pleasure also to make grateful acknowledgment here of the services rendered by Señor Luis G. y Carbonell, chief of the meteorological service at Habana, Cuba, while the storm was passing through the Caribbean Sea. Señor Carbonell responded promptly to every request for special observations from various points in Cuba, often at inconvenient hours, and the data were of great assistance to the forecaster.

The following press comments relative to the work of the Weather Bureau in connection with the storm are indicative of the uniform character of the large number that was received:

New Orleans, La., Daily States, August 20, 1915 (editorial):

One of the most fortunate phases of the great tropical storm is the small loss of life, relatively speaking, which it left in its wake.

In the storm of 1900, six thousand was the death toll in Galveston alone, and two or three thousand more perished elsewhere, most of them on the Texas mainland. This year, although the storm was of a severity comparable with that of 15 years ago, the total deaths in Galveston, on the mainland and the sea seem likely to run under 300.

In 1900 there was some criticism of the Government, not entirely justified, for its warnings of the storm. But no such criticism lies in connection with this year's storm. If the loss is small, considering the duration and fury of the blow, immeasurable credit is due the Government forecasters for the remarkable accuracy with which they outlined the track of the storm and the ample opportunity they gave not only to shipping but to those on land to protect themselves.

In consequence, shipwrecks have been conspicuously few. Vessels at sea had time to run for cover. Those in ports were enabled to postpone their departure until the actual danger was passed.

Not only at Galveston but all along the coast, even at remote points, messages of the Weather Bureau were received in plenty of time to let the cautious seek places of safety; and no one doubts that, admitting fully the part the seawall played, the exodus of thousands, due to the accuracy of the Bureau's warnings, was one of the factors which held the Galveston fatalities down to such small figures.

Rochester, N. Y., Union and Advertiser, August 21, 1915 (editorial):

Many lives were saved at Galveston by the warning of the approaching storm issued by the Weather Bureau. According to dispatches, the forecaster not only predicted the hurricane, but sent men on motor cycles to various sections, notifying the inhabitants to seek safer places of refuge if they hoped to save their lives. The warning was heeded by the vast majority and they lived to tell the story; by some it was ignored, and they perished because of their heedlessness. Only Galveston's seawall was more effective than the Government Weather Bureau in preventing a repetition of the disaster of 1900, when 4,000 persons were killed.

The incident makes some of the fun that is poked at weather forecasters in all sections of the country sound a little cheap. It puts to shame some of us who have been over zealous in enumerating the mistakes of the forecasters and lax in giving credit to their accuracy. The Galveston incident is the most striking example of the real value of the Bureau that has come up in many years, but not a storm sweeps across the country that is not preceded by property-saving and life-saving warnings. The next time the "weather man" fails to predict a thunder shower that spoils our picnic, let's remember the lives he saved at Galveston.

Galveston, Tex., Daily News, August 17, 1915:

* * * Heralded for two full days in advance by the United States Weather Bureau, the storm did not take Galveston unaware or find it unprepared. Warned repeatedly and thoroughly by the local weather forecaster, W. P. Stewart, every man, woman, and child had ample time in which to seek places of safety in the larger buildings of the business and central residence district, and it was largely due to this fact that none were caught in the wrecked houses on the beach front.

Houston, Tex., Post, August 22, 1915:

In the retrospection after the storm, when the work of searching out the dead and missing is still going on, there remains to be told the story of the part played by the United States Weather Bureau and especially by the stations in Houston and along the coast. When this story is told it will be learned why the loss of life is not considerably greater.

Those who watched the bulletins of the department since the first warning was issued a week before the storm struck Texas, will recall with what prophetic accuracy its direction, its nature, and its violence were heralded to the people of Houston from day to day. Good work was accomplished by the display men in the various substations along the coast, who not only posted the warnings but personally advised the people in the small communities to take the necessary precautions.

An instance of this was the work of W. B. Stearns, the display man at Seabrook, who made the rounds of the flats in that section and urged the people to leave for the high ground. This is simply one example of similar efforts on the part of all the display men in the district.

Probably no more daring feat was performed during the storm than that of two assistants in the office of Dr. Bunnemeyer in the Stewart Building. When the storm was at its height Tuesday morning the anemometer which records the velocity of the wind was put out of commission at 4:35 o'clock. At 5:50 the two men clambered to the roof and replaced the equipment with a new one. The record immediately after showed that the wind was blowing 80 miles an hour, the highest during the entire storm.

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, AUGUST, 1915.

By ALFRED J. HENRY, Professor of Meteorology, in Charge of River and Flood Division.

[Dated: Weather Bureau, Sept. 30, 1915.]

High summer stages in the Mississippi below Cairo.—The annual spring rise in the lower Mississippi for 1915 fell short of a flood stage; the maximum stage on March 1 being about 1 foot less than flood stage at Vicksburg. From that date the river fell slowly, until May 27, reaching a minimum stage of 17.8 feet. A slow but steady rise then set in, cresting at 41.7 feet June 21, with a second crest stage of 41.4 feet on July 10 and a third, of 40.1 feet on September 7. The low water for the summer months was:

June.......... 24.4 ft. on the 1st.
July.......... 38.0 ft. on the 31st.
August........ 32.3 ft. on the 18th.

The last named is also the low stage between the dates June 5 and September 16, a period of 103 days during the summer season when much lower water is the rule. This is an extraordinary record and is not paralleled within the last 41 years. The nearest approach to it was during the summer of 1875. At that time, although the maximum stage was less than in 1915, yet, according to Section Director Barron, of the Vicksburg station, a greater volume of water was carried by the river at that time. There was then no continuous levee on the west bank of the river in the Vicksburg district, consequently thousands of acres of cotton when the plant was full grown and heavily fruited were submerged.

The flood of 1915, however, while not overflowing to exceed 1,000 acres of farm land, all of which was outside the levees, materially interrupted the construction work of the Mississippi River Commission.

The 1875 flood was due to a very considerable summer flood out of both the Ohio and the Missouri, while the high water of 1915 was due to heavy rains over the western tributaries and in the immediate watershed of the Mississippi between St. Paul and Cairo only. The final swell of 1915 came as a result of torrential rains in Arkansas and southeastern Missouri in connection with the West Indian hurricane of August 13-23. (See p. 411 of this REVIEW.)

Floods in connection with the West India hurricane of August 13-23.—The above named, in its course northeastward from the Texas coast, was associated with heavy rains, particularly to the northwest and north of its center, the regions of heavy rains and dates being as follows:

17th. East Texas and northern Louisiana.

18th. East Texas, northern Louisiana and eastern Oklahoma, Arkansas, western Tennessee and Kentucky.

19th. East Texas, northern Louisiana, Arkansas, Tennessee, western Kentucky, and southern Missouri.

20th. Western Tennessee and Kentucky, southern Missouri, southern and central Illinois and Indiana.

21st. Lower Ohio Valley.

The total duration of the rains was 36 to 72 hours. In the beginning the rains were light to moderate; in the last 36 hours, however, they were heavy but the latter characteristic was not noticed after the storm center passed beyond the Ohio Valley on the 22d.

The distribution of precipitation about the center of a tropical cyclone (or West India hurricane) is uniform, while the cyclone is in equatorial region; in this particular the tropical cyclone differs from the extra tropical. In the storm of the 13th-23d, the tropical characteristic as regards the distribution of precipitation about the center was seemingly maintained until the storm center reached the lower Ohio Valley, although there were sections in its path where the precipitation was both less intense and less uniformly distributed than at others. Thus in Arkansas the rains were quite heavy in the southwest portion of the State, considerably less intense in the storm's path through the middle portion of the state as it crossed the valley of the Arkansas River. The intensity of the precipitation was again renewed, however, in the northeastern portion of the State and the adjoining portion of Missouri. This fact has an important bearing on the floods in Arkansas rivers, as will appear later in this report.

Texas rivers.—Only the rivers of extreme east Texas were affected, and these only to a rather slight extent, as may be seen from the details in the table below:

TABLE 1.—*Flood stages in rivers of Texas, August, 1915.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet*	
Trinity	Dallas, Tex	25.0	20	21	....	....
			28	30	30.0	29
Do	Liberty, Tex	25.0	20	25	25.8	23, 24
Neches	Rockland, Tex	20.0	19	20	21.4	19
Do	Beaumont, Tex	7.0	18	31	14.0	23
Sabine	Logansport, La	25.0	19	25	30.8	23
Do	Merryville, La	20.0	....	....	19.9	24, 25 28, 29
Do	Orange, Tex	4.0	17	31	6.1	23, 24

The Red River and its tributaries, responding to a rather uniform distribution of heavy rains on the three days—17th to 20th—showed stages that as a rule fell short of the flood stage or slightly exceeded it, as also shown in the table. The upper Ouachita, above Camden, Ark., rose to a stage that overflowed the lowlands in the vicinity of Arkadelphia, Ark., but the flood stage in the lower reaches of the stream was not reached.

TABLE 2.—*Flood stages in Red River and tributaries, August, 1915.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Red	Fulton, Ark	28.0	22	29	31.4	24
Do	Spring Bank, Ark	29.0	....	....	28.8	30, 31
Sulphur	Ringo Crossing, Tex	20.0	....	....	19.3	21
Do	Finley, Tex	24.0	24	29	26.5	24, 25
Ouachita	Arkadelphia, Ark	18.0	20	22	21.4	21
Do	Camden, Ark	39.0	....	....	36.0	25
Little	White Cliffs, Ark	28.0	21	23	32.0	21

The Arkansas between Fort Smith and Pine Bluff was slightly above flood stage, except at the last-named point. The White, an important tributary that enters the Arkansas on the left bank near the junction of the latter with the Mississippi, reached the highest known stages at points along the upper and middle stretches of the stream. At Calico Rock the previous record of 43.1 feet, on February 14, 1884, was exceeded by 8 feet; at other points the excess above previous high water was much less. These remarkable stages were caused by continued heavy rains over the upper watershed of the White, the total fall in the three days August 17-20 being 10 inches or more. As previously stated, the intensity of the precipitation in connection with the West India hurricane of August 13-23 was markedly different in portions of its path through Arkansas, diminishing from 10 inches in Polk and Howard Counties to less than 6 inches in Faulkner, Cleburne, Pulaski, Jefferson, Arkansas, White, Woodruff, and Monroe Counties, in the valley of the Arkansas River, in the central part of the State. It is possible that the increased precipitation in Arkansas was due to topographic features, since many of the heaviest falls were reported along the eastern edge of the Ozarks, which here rise 500 to 1,000 feet above the valleys in the eastern part of the State.

TABLE 3.—*Flood stages in Arkansas River and tributaries, August, 1915.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Arkansas	Dodge City, Kans	5.0	26	26	5.3	26
Do	Fort Smith, Ark	22.0	20	21	24.5	20
Do	Dardanelle, Ark	20.0	21	23	23.0	21
Do	Little Rock, Ark	23.0	22	24	23.8	22
Do	Pine Bluff, Ark	25.0	....	....	24.8	25
White	Calico Rock, Ark	18.0	20	24	51.0	21
Do	Batesville, Ark	18.0	20	25	37.8	21
Do	Newport, Ark	26.0	22	31	33.9	24
Do	Georgetown, Ark	22.0	24	31	26.2	27, 28
Do	Clarendon, Ark	30.0	31	31	31.6	31
Black	Black Rock, Ark	14.0	20	31	31.9	21
Fourche la Fave Creek.	Bigelow, Ark	23.0	22	27	28.2	24

The Meramec of Missouri.—This stream has its origin in the eastern foothills of the Ozarks, in the southwestern part of Missouri, and flows in a northeasterly course, discharging into the Mississippi about 20 miles south of St. Louis. The Weather Bureau does not maintain any station along its course. The following account of the flood was extracted from the Engineering News of September 21, 1915:

The rain of August 19-21, in the St. Louis district, caused disastrous floods in the Meramec River to the south and west of the city, the greatest damage probably occurring at Valley Park, about 20 miles to the southwest.

According to the best reports the river rose about 7 feet on the night of the 19th and about 17 feet additional on the 20th. It was practically stationary during Saturday, the 21st, and it was generally assumed that high water had been reached, but during the night of the 21st and the day of the 22d an additional rise of 19 feet occurred, making a total of 43 feet above low water. This submerged practically the whole town well above the ordinary second-story level, and a large part of the rise having come during the night, it appears that a majority of the people were marooned in their own houses. As far as can be ascertained, however, no lives were lost, but the damage to property was enormous.

This stage of the Meramec was probably partly a result of the condition of the Mississippi River, into which the former discharges 20 miles below Valley Park. The Mississippi rose from a stage of 22 feet on Thursday to a stage of 30 feet on Sunday.

According to newspaper reports 20 persons were drowned in various parts of St. Louis County, due to the floods of the 20th to 22d. In East St. Louis much farm land was overflowed by the breaking of the Wood River levees on the 21st. A part of the new levee at East Alton also gave way, flooding the lowlands and endangering lives, but prompt action prevented great loss of life.

The Erie flood.—Probably the most destructive local flood of the month occurred on August 3, in connection with a series of thunderstorms in northwestern Pennsylvania. The rainfall at Erie, Pa., was 5.57 inches in about 15 hours, resulting in a serious overflow of Mill Creek and the loss of much property and 30 lives.

The details of high water in the Mississippi and its tributaries, in which a flood stage was reached, appear in the table below.

TABLE 4.—*Flood stages in Mississippi River, August, 1915.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Mississippi	Keokuk, Iowa	14.0	1	1	15.2	1
Do	Warsaw, Ill	17.0	3	3	17.7	3
Do	Quincy, Ill	14.0	1	8	15.9	4
Do	Hannibal, Mo	13.0	1	11	16.1	5
Do	Grafton, Ill	18.0	3	12	19.9	6, 7
Do	St. Louis, Mo	30.0	5 21	6 23	.... 30.6	 21
Do	Chester, Ill	30.0	23	25	30.7	24
Do	Cape Girardeau, Mo	30.0	5 21	10 28	.... 34.2	 25
Do	Arkansas City, Ark	42.0	30	31	42.5	31

TABLE 5.—*Flood stages in Illinois, August, 1915.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Illinois	La Salle, Ill	18.0	1	31	24.2	5
Do	Peoria, Ill	16.0	4	17	18.5	8
Do	Beardstown, Ill	12.0	1	31	14.8	30, 31

TABLE 6.—*Flood stages in Missouri River and tributaries, August, 1915.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Missouri	Kansas City, Mo	22.0	1	10	26.4	1
Do	Waverly, Mo	23.0	1	3	24.0	2
Do	Boonville, Mo	21.0	1	11	22.9	3
Do	Hermann, Mo	21.0	3	4	21.1	4
Smoky Hill	Abilene, Kans	22.5	....	....	22.2	5
Do	Lindsborg, Kans	20.0	15	15	20.0	15
Republican	Clay Center, Kans	18.0	4	6	18.7	6
Grand	Chillicothe, Mo	18.0	1	9	27.0	5
Gasconade	Arlington, Mo	12.0	20	22	26.4	22

Floods in rivers of the South and East.—The table below shows the essential facts in connection with high water in the streams named. The flood in the White River of Indiana was due to the precipitation that occurred in connection with the West Indian hurricane before mentioned; the remaining floods were mostly due to heavy local rains in the respective watersheds.

TABLE 7.—*Flood stages in various rivers, August, 1915.*

River.	Station.	Flood stage.	Above flood stage. From—	Above flood stage. To—	Crest. Stage.	Crest. Date.
		Feet.			*Feet.*	
Chattahoochee	Eufaula, Ala	4.0	20	21	....	....
			23	24	4.5	20
Wateree	Camden, S. C	24.0	13	13	24.4	13
Santee	Rimini, S. C	12.0	24	25	12.5	24
Do	Ferguson, S. C	12.0	19	20	....	....
			25	26	12.1	26
Roanoke	Weldon, N. C	30.0	14	14	30.4	14
Staunton	Randolph, Va	21.0	....	....	20.8	13
White	Elliston, Ind	19.0	15	17	....	....
			22	25	21.3	24
St. Joseph	Montpelier, Ohio	10.0	23	23	10.0	23
Conoquessing Creek	Ellwood City, Pa	10.0	4	4	10.2	4
Connecticut	Hartford, Conn	16.0	6	6	16.5	6

Loss of life and property.—Between 50 and 60 persons lost their lives during the month by reason of floods. Thirty of this number perished in the Erie, Pa., catastrophe, and 20 more were drowned in St. Louis County, Mo., by the overflow of the Meramec and Des Peres Rivers.

The property loss is uncertain at best. Systematic efforts to arrive at an approximate figure are made by officials in charge of river district centers. These show an approximate loss of about four millions, distributed as shown in the table below; while out-of-hand estimates, made by newspaper reporters, show additional losses aggregating about four millions, distributed as follows: Erie, Pa., $3,000,000; St. Louis County and western Illinois, $1,000,000; making an aggregate of about $7,000,000 for the month.

Property loss by flood, August, 1915.

District.	Tangible property, bridges, etc.	Crops. In hand.	Crops. Prospective.	Movable property (live stock).	Suspension of business.	Saved by warnings.
Little Rock, Ark	$371,250	$608,250	$1,138,300	$38,600	$70,000	....
Fort Smith, Ark	15,000	10,200	85,000	500	....	$5,500
Shreveport, La	75,000	30,000	375,000	3,000	150,000	[a]350,000
Columbia, S. C	....	....	....	....	....	8,200
Total	461,250	648,450	1,598,300	42,100	220,000	363,700

[a] Mostly live stock.

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

MEAN LAKE LEVELS DURING AUGUST, 1915.

By United States Lake Survey.

[Dated: Detroit, Mich., Sept. 4, 1915.]

The following data are reported in the Notice to Mariners of the above date:

Data.	Lakes. Superior.	Lakes. Michigan and Huron.	Lakes. Erie.	Lakes. Ontario.
Mean level during August, 1915:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.41	580.11	572.34	245.43
Above or below—				
Mean stage of July, 1915	+0.12	+0.19	+0.26	+0.30
Mean stage of August, 1914	−0.34	−0.52	−0.22	−0.90
Average stage for August, last 10 years	−0.23	−0.87	−0.32	−1.21
Highest recorded August stage	−1.52	−3.40	−1.77	−2.83
Lowest recorded August stage	+0.81	+0.26	+0.96	+1.08
Probable change during September, 1915	+0.1	−0.2	−0.3	−0.4

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR AUGUST, 1915.

By W. J. HUMPHREYS, Professor in charge of Seismological Investigations.

[Dated: Weather Bureau, Washington, D. C., Sept. 30, 1915.]

TABLE 1.—*Noninstrumental earthquake reports, August, 1915.*

[Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.]

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
	H. m.		° ′	° ′			Sec.			
5	16 30	Drakesbad	40 28	121 29	5	1	1	Rumbling		A. Sifford.
	18 33	Spreckles	36 32	121 38	3-4	2	2		Windows rattled	Mrs. A. Boncquet.
6	18 40	Mineral	40 21	121 32	2	1	2			Frank C. Hardin.
		NORTH DAKOTA.								
8	15 15	Williston	48 09	103 35	3	1			Awakened by shock	Miss Florence Dennett.
	15 15	Williston	48 09	103 35	4	1	3		Rattled dishes	Rev. I. G. Monson.
	15 15	Williston	48 09	103 35	3	1	5		Rattled dishes	W. H. Shemorry.
	15 15	Williston	48 09	103 35	3-4	1	2		Shook house	Geo. F. Carpenter.
	15 15	Williston	48 09	103 35	3	1				C. F. Anderson.
	15 15	Williston, R. F. D	48 08	103 36	3	1		Rumbling		R. C. Ike.
		UTAH.								
11	10 20	Iosepa	40 32	112 44	7	1	10	Rumbling		James K. Halemanu.
		WASHINGTON.								
18	14 04	Glacier	48 54	121 57	4	2	6	Faint	Origin in southern British Columbia.	C. C. McGuire.
	14 04	Lakeside	47 50	120 00	3	1		Faint		W. H. Van Meter.
	14 04	Laurier	48 59	118 13	4	1				Mrs. J. S. Myers.
	14 04	Marblemount	48 32	121 26	5	1	5	Loud		Henry Soll.
	14 04	Seattle	47 38	122 20	2	1	3			U. S. Weather Bureau.
18	18 00	Marblemount	48 32	121 26	3	1	1	Faint		Henry Soll.

TABLE 2.—*Instrumental reports, August, 1915.*

[Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.]

[For significance of symbols see REVIEW for June, 1915, p. 289.]

Alaska. *Sitka. Magnetic Observatory.* U. S. Coast and Goedetic Survey. J. W. Green.

Lat., 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: $\begin{cases} E & 10 & 17.4 \\ N & 10 & 15.6 \end{cases}$ (V, T_0)

No earthquakes recorded during August.

Arizona. *Tucson. Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat., 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: $\begin{cases} E & 10 & 16 \\ N & 10 & 19.6 \end{cases}$ (V, T_0)

No earthquakes recorded during August.

California. *Berkeley. University of California.*

Lat., 37° 52′ 16″ N.; long., 122° 15′ 37″ W. Elevation, 85.4 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Mount Hamilton. Lick Observatory.*

Lat., 37° 20′ 24″ N.; long., 121° 38′ 34″ W. Elevation, 1,281.7 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Point Loma. Raja Yoga Academy.* F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

Report for August, 1915, not received.

California. *Santa Clara. University of.* J. S. Ricard, S. J.

Lat., 37° 26′ 36″ N.; long., 121° 57′ 03″ W. Elevation 27.43 meters.

(See Record of the Seismographic Station, University of Santa Clara.)

TABLE 2.—*Instrumental reports, August, 1915*—Continued.

Colorado. *Denver. Sacred Heart College.* Earthquake Station. A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 1	I_u	e	10 15 00					Irregular waves on N-S.
		F_N	10 20 00					
2		e	8 05 00					Wavelets at intervals.
		F_N	15 00 00					
5		e	21 02 00					Very irregular waves.
		F_E	21 20 00					
9	I_u	e	17 20 00					Very small sinusoidal waves.
		F_N	17 22 00					
9	I_u	eP_N	20 06 00					
		M_N	20 10 00	15				
		F_N	20 11 00					
10	I_u	e	10 50 00					Very small sinusoidal waves, irregular on E-W.
		F_N	11 00 00					
12	I_u	e	10 00 00					Sinusoidal waves at intervals—long period with very small amplitude.
		F_N	11 00 00					
18	I_u	e	13 04 00					Earthquake reported from British Columbia.
		F_N	13 08 00					
18		e	13 24 00	26				Thickening of pen marks on E-W.
		F_N	13 27 00					
20	I_u	e	7 00 00	20-35	4	7		Almost continual activity, especially on N-S.
		F_N	15 00 00					
25		e	16 00 00	20-30	4	4		
27		e	12 20 00	10-15				Very small sinusoidals at intervals on N-S. Irregular on E-W.
		F_N	15 15 00					
29		e	11 20 00					Long waves at frequent intervals.
		F_E	15 00 00					
31		e	12 40 00					Irregular long period waves on N-S. Less visible on E-W.
		F_N	15 30 00					

District of Columbia. *Washington. U. S. Weather Bureau.*

Lat., 38° 54′ N.; long., 77° 03′ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

Instrumental constants.. V 110 T_0 6

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 3		P	13 26 48					
		S	13 31 48					
3		eL	14 09 00					P and S not discernible.
		eL	14 20 00					
		F	14 50 00					
6		P	13 25 14					S lost while changing sheets.
		PR1	13 28 28					
		eL	13 59 00					
		L	14 20 00	20				
		F	14 50 00					
7		P	15 24 26					Other phases not discernible.
		F	15 45 00					
16		P?	1 16 44					
		L	1 30 00					
		L	1 36 00	20				
		F	2 10 00					
19		P	0 16 50					
		L	0 32 00					
		F	0 45 00					

District of Columbia. *Washington. Georgetown University.* F. L. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg. astatic horizontal pendulums.

Instrumental constants:	V	T_0	ε
E	165	5.4	2.6
N	143	5.2	3.4

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 6	I_r	e	13 58 44					E-W barely discernible.
		L_N	14 06 00					No distinct maximum.
		L_E	14 06 15					
		F_N	14 49 02					

Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wm. W. Merrymon.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instrument: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant.. T_0 18.8

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 3		P	13 16 36					
		S	13 26 42					
		L	13 37 30	22				
		M	13 46 12		*3,900			
		C	14 11 30					
		F	16 31 24					
6		P	13 28 18					
		S	13 33 00					
		L	13 38 18	24				
		M	13 40 30		*2,300			
		C	13 53 48					
		F	15 06 42					
10		eP	2 59 42					
		M	3 05 24		*200			
		C	3 09 30					
		F	3 42 18					
12		P	7 59 36					
		L	8 19 24					
		M	8 24 54		*400			
		C	8 33 00					
		F	8 55 00					
12		eL	10 09 00					
		M	10 19 30		*100			
		F	10 32 00					
16		P	1 09 06					
		S	1 11 00					
		L	1 13 18	23				
		M	1 18 12		*1,200			
		C	1 28 36					
		F	2 15 30					
19		eL	1 04 24					
		M	1 10 42		*100			
		F	1 26 54					Record lost from Aug. 21, 1^h 34^m to Aug. 22 18^h 26^m.
31		eP	21 03 18					
		L	21 22 30					
		M	21 28 18		*200			
		C	21 32 42					
		F	22 02 00					

* Trace amplitude.

Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 304.8 meters.

Instrument: Wiechert.

Instrumental constants..	V	T_0	ε
E	177	3.7	4.0
N	205	3.7	3.8

No earthquakes recorded during August, 1915.

TABLE 2.—*Instrument reports, August, 1915*—Continued.

Maryland. *Cheltenham. Magnetic Observatory.* U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants	V	T_0
E	10	31
N	10	29

No earthquakes recorded during August.

Massachusetts. *Cambridge. Harvard University Seismographic Station.* J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums, undamped (mechanical registration).

Instrumental constants	V	T_0
E	80	23
N	50	25

Report for August, 1915, not received.

Missouri. *St. Louis. St. Louis University.* Geophysical Observatory J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation, 12 feet of tough clay over limestone of Mississippi System, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

	V	T_0	ϵ: 1
Instrumental constants	80	7	5: 1

Report for August, 1915, not received.

New York. *Buffalo. Canisius College.* John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert 80 kg. horizontal.

	V	T_0	ϵ: 1
Instrumental constants	80	7	5: 1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 8			19 15 00					
			23 45 00					Microseisms E-W.
11	I_r	P_E	10 06 30					
		S_E	11 11 15					
		M_E	10 14 45	10	19		3,450	
		C_E	10 21 30					
		P_N	10 11 15					Not discernible.
		S_N	10 14 45	8				
14		M_N	8 48 00					Intermittent microseisms E-W.
			18 00 00					

New York. *Fordham. Fordham University.* W. C. Repetti, S. J.

Lat., 40° 57′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 23.9 meters.

Instrument: Wiechert 80 kg.

Instrumental constants	T_0
E	6.6
N	7.1

Report for August, 1915, not received.

Panama Canal Zone. *Balboa Heights.* Isthmian Canal Commission.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, ——.

Instruments: Two Bosch-Omori 100 kg.

	V	T_0
Instrumental constants	10	20

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 31		P	21 33 40					
		L	21 35 00					
		M	21 35 35		200		620	
		F	21 36 25					

Porto Rico. *Vieques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. H. M. Pease.

Lat. 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

Instrumental constants	V	T_0
E	10	21.4
N	10	21.1

No earthquake recorded during August.

Vermont. *Northfield. U. S. Weather Bureau.* Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants	V	T_0
E	10	15
N	10	16

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 3		P?	13 26 33					
		S?	13 31 33					
		L	13 36 30					
		F	14 00 00					
6		P	13 24 56					S not discernible.
		F	14 00 00					
7		P	15 23 52					
		S	15 31 10					
		L	15 45 30	18				
		F	16 00 00					
16		P	1 16 23					
		S?	1 21 09					
		L	1 40 00	16				
		F	2 00 00					
19		P?	0 17 15					Mere trace, all phases doubtful.

Table 2.—*Instrumental reports, August, 1915*—Continued.

Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz.

Lat., 42° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

Instrumental constants.. V 120 T_0 26

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	*μ*	*μ*	*Km.*	
1915. Aug. 3		P	13 26 22				3,240	
		S	13 31 22					
		L	13 36 01	20				
		L	14 02 00	24				
		L	14 20 00	20				
		L	14 32 00	18				
		F	15 35 00					
6		P	13 24 48	3			9,150	
		PR1	13 28 06					
		S	13 35 07					
		L	13 55 02	28				
		L	14 07 00	18–16				
		L	14 13 00	16				
		F	15 00 00					
7		P	15 23 58				5,600	
		S_N	15 31 12					
		L	15 37 00	30				
		L	15 38 00	28				
		L	15 43 00	18				
		L	15 53 00	14				
		F	16 10 00					
11		L	9 45 00	40				Very distant, inferred from deformation instrument.*
16		e_N	1 15 44				3,500?	
		e_E	1 15 48					
		S?	1 21 00					
		L	1 26 00	20				
		L	1 30 00	24–22				
		L	1 37 00	15–14				
		L	1 51 00	14–13				
		L	2 00 00	15–13				
		F	2 20 00					
19		P?	0 16 32				5,550?	
		S_E?	0 23 42					
		S_N?	0 23 44					
		L_N	0 33 02	20				
		L	0 52 00	40				
		L	0 56 00	30				
		L	0 58 00	28				
		L	1 00 00	20				
		L	1 06 00	18				
		F	1 20 00					
22		L	9 36 00	40				
		F	9 55 00					
22		L	11 31 00	28				
		F	11 50 00					

* Instrument just mounted in special vault for study of deformation of the earth by moon and sun; hence expression "deformation" instrument.

Canada. *Toronto. Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long, 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrument constant: T_0 18. Pillar deviation, 1 mm. swing of boom=0.59″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	*μ*	*μ*	*Km.*	
1915. Aug. 3		P	13 27 18					
		S	13 33 18		*200			
		L	13 43 30					
3		P	?14 00 12					Possibly dual earthquakes.
		S	14 02 18					P may be mixed up with trailers.
		iL	14 13 06					
		iL	14 18 54					
		M	14 24 30		*2,200			
		Repeat	15 19 12					
		F	15 46 54					

*Trace amplitude.

Canada. *Toronto. Dominion Meteorological Service*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	*μ*	*μ*	*Km.*	
1915. Aug. 6		P	13 44 48					
		S	13 51 00					
		L	13 58 54					
		M	14 08 24		*800			
		F	14 55 06					
7		P	?15 31 42					P doubtful.
		S	15 39 54					
		iL	15 46 42					
		M	15 49 30		*800			
		F	16 11 24					
10		P	?2 40 00					
		S	2 44 18					Beginning not well defined.
		L	2 45 36					
		M	2 47 18		*800			
		F	2 59 24					
11		L	9 52 18					Minute thickening.
		F	9 59 30					
16		P	1 15 06					
		L	1 30 12					
		iL	1 31 54					
		M	1 33 48		*300			
		L	1 37 06					
		L	1 49 30					
		M	1 50 24		*300			
		F	2 42 00					
19		P?	?0 21 24					
		L?	0 45 54					
		L	1 07 06		*200			Watch hand touching boom interfered with some phases.
		F	1 45 30					

*Trace amplitude.

Canada. *Victoria, B. C. Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant: T_0 18. Pillar deviation, 1 mm. swing of boom=0.54″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	*μ*	*μ*	*Km.*	
1915. Aug. 3		P	13 34 26				9,600	
		S	13 51 46					
		L	13 59 26					
		M	14 08 56		*1,500			
		F?	16 49 56					
6		P	13 40 18					
		L	13 49 18					
		M	13 52 18		*500			
		F	14 54 18					
7		P	15 27 21				10,600?	
		S	15 46 51					
		L	15 52 21					
		M	15 56 21		*500			
		F	16 20 21					
10		P?	2 45 30					P. Doubtful.
		L	2 51 30					Not recorded on vertical seismograph.
		M	2 59 30		*300			
		F	3 23 00					
16		S?	1 09 25					
		L	1 15 25					
		M	1 16 25		*400			
		F	2 48 55					
18		P	14 05 00				80	Eq. felt in Victoria, vibration of 1 sec., also along Fraser Valley and Puget Sound.
		S	14 05 20		*100			
		L	14 05 20					
		M	14 05 20					
		F	14 08 00					
19		P	1 03 01				13,000	
		S	1 16 01					
		L	1 22 01					
		M	1 23 01		*100			
		F	1 43 01					

*Trace amplitude.

TABLE 3.—*Late seismological reports.* (*Instrumental.*)

Porto Rico. *Vieques.* *Magnetic Observatory.* U. S. Coast and Geodetic Survey. H. M. Pease.

Lat., 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

Instrumental constants.. $\begin{cases} E & 10 & 21.4 \\ N & 10 & 21.1 \end{cases}$ (V, T_0)

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 31	......	L_E	2 20 00	......	......	......	......	
		L_N	2 22 24	26	......	......	......	
		M_E	2 26 10	20	10	......	......	
		M_N	2 29 10	20	......	50	......	
		C	2 38 00	......	......	......	......	

Canada. *Toronto.* *Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.59″.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 20	......	P?	16 04 54	......	......	......	......	
		L	16 09 48	......	* 100	......	......	
		F	16 15 00	......	......	......	......	
22	......	L	4 30 24	......	* 100	......	......	Air currents going on before L begin.
		F	4 40 42	......	......	......	......	
25	......	P	21 04 18	......	......	......	......	
		S?	21 08 48	......	......	......	......	
		L	21 16 36	......	......	......	......	
		L	21 19 48	......	......	......	......	
		M	21 22 30	......	* 400	......	......	
		M	21 47 42	......	......	......	......	
		F	21 51 12	......	......	......	......	
31	......	P	1 41 48	......	......	......	8,325	A marked disturbance. Long waves continued for a long time. Four distinct maximums recorded. Origin near Kurile Islands.

* Trace amplitude.

Canada. *Toronto.* *Dominion Meteorological Service*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 31	......	S	1 51 48	......	......	......	......	
		L	2 01 00	......	......	......	......	
		L	2 05 30	30-18	......	......	......	
		L	2 10 36	......	......	......	......	
		M	2 11 42	18-24	*3,400	......	......	
		L	2 13 54	......	......	......	......	
		M	2 15 06	18	*3,800	......	......	
		M	2 17 24	......	*3,200	......	......	
		L	2 20 42	......	......	......	......	
		M	2 22 06	12-18	*2,800	......	......	
		L	2 39 36	......	......	......	......	
		L	3 43 48	......	......	......	......	
		F	5 20 48	......	......	......	......	

* Trace amplitude.

Canada. *Victoria, B. C.* *Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation: 1 mm. swing of boom=0.54″.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
July 20	......	P	16 07 48	......	......	......	......	
		L	(?)	......	......	......	......	
		M	16 07 54	......	* 100	......	......	
		F	16 12 54	......	......	......	......	
22	......	P	4 25 54	......	......	......	......	
		S	4 29 54	......	......	......	......	
		L	4 36 24	......	......	......	......	
		M	4 40 54	......	* 300	......	......	
		F	4 55 24	......	......	......	......	
25	......	P	20 59 48	......	......	......	......	
		S	21 01 48	......	......	......	......	
		L	21 02 48	......	......	......	......	
		M	21 31 48	......	* 500	......	......	
		F	21 18 18	......	......	......	......	
31	......	P	1 39 48	......	......	......	3,800	Origin near Kurile Islands.
		S	1 46 24	......	......	......	......	
		L	1 50 36	......	......	......	......	
		M	1 57 48	......	*3,800	......	......	
		F	5 11 48	......	......	......	......	

* Trace amplitude

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. Fitzhugh Talman, Professor in charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies.

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RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. Fitzhugh Talman, Professor in charge of Library.

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only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

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SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

P. C. Day, Climatologist and Chief of Division.

[Dated: Weather Bureau, Washington, Oct. 2, 1915.]

PRESSURE.

The distribution of the mean atmospheric pressure over the United States and Canada, and the prevailing direction of the winds are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

For the month as a whole the barometric pressure was near or slightly below the normal over most sections east of the Mississippi River, except the upper Lake region, northern New England, and the Canadian Maritime Provinces. It was also low over the west Gulf States, the greater part of the Plateau region, and in the far Southwest. Over all other portions of the country average pressure was above normal, the greatest plus departures appearing in the eastern Rocky Mountain and western Plains regions.

The month opened with relatively high pressure over the northern portions of the country and to the westward of the Rocky Mountains. Elsewhere it was near the normal, except in the extreme Southeast moderately low pressure obtained. During the first decade the pressure continued high throughout most districts to westward of the Mississippi, while it was generally below the normal to the eastward. During the second decade relatively high pressure continued in most northern and western sections, while to the southward it was slightly below the normal until the latter part of the decade, when the movement of the subtropical storm across this region caused abnormally low pressure, which conditions continued until near the middle of the third decade. During the remainder of the month relatively high pressure prevailed generally throughout the Plains States and to the westward, while elsewhere the pressure was near the normal until the last few days of the month, when a rather extensive high area overspread most central and eastern districts.

The distribution of the highs and lows was generally favorable for southerly and southwesterly winds along the immediate Atlantic and Gulf coasts, except the Florida Peninsula, southwesterly in the upper Ohio Valley and lower Lake region, and northwesterly along the Pacific coast. Elsewhere variable winds prevailed.

TEMPERATURE.

The month opened with high temperatures over the more eastern and southern districts and with decidedly cool summer weather from the upper Lake region westward to the Rocky Mountains and over the northeastern States. In other portions of the country the temperatures were near the normal. A cool wave gradually overspread the interior portions of the country and shortly after the middle of the first decade cooler weather extended into all districts to the eastward of the Rocky Mountains. During the latter part of the decade moderately cool weather prevailed in nearly all central and eastern districts with a tendency to warmer, and by the close of the decade normal summer temperatures were the rule in practically all parts of the country, except that unusually warm weather prevailed in some interior districts of the Pacific Coast and Plateau States.

The average temperatures for the decade were below the normal over much of the country to eastward of the Rocky Mountains, but along the South Atlantic and Gulf Coasts the decade was moderately warm, and to westward of the Rocky Mountains it was likewise above normal.

During the first few days of the week ending August 17 high temperatures prevailed over the interior portions of the far West, but as the week advanced there was a slight lowering, so that toward the end temperatures in those districts were near the normal. Over the districts to the eastward of the Rocky Mountains the week opened with moderate summer temperatures in nearly all portions and only slight changes occurred thereafter, except locally, due to the influence of thunderstorms or otherwise. Toward the latter part of the week slightly cooler weather occurred along the northern border and in portions of the mountain regions of the West, and by the end of the week much colder weather prevailed in the upper Lake region and to the eastward and the westward. Over other portions of the country the week closed with temperatures generally near the normal.

The mean temperatures for the week were equal to or above the seasonal normal in the northern Plains States and upper Mississippi Valley, and the week was generally warm over the eastern third of the country, as well as over the middle and northern Plateau and Pacific States. However, in the middle portions of the Plains region and Mississippi Valley the week continued cool.

The week ending August 24, opened with temperatures ranging from 5 degrees to 15 degrees below the seasonal average over northern districts from the Mississippi River eastward. As the week advanced there was a slight warming up, and shortly after the middle temperatures had become decidedly higher in the Middle Atlantic States and the upper drainage area of the Ohio River, but over interior districts comparatively cool weather for the season continued. During the latter part of the week moderate temperatures obtained over nearly all districts, while to the westward of the Rocky Mountains warm weather prevailed quite generally throughout the week. At the close considerably cooler weather overspread the Northwest, and light frosts were reported from points in North Dakota and Wyoming.

For the week as a whole, the average temperatures were below the normal over most sections east of the Rocky Mountains, save in the coastal portions of the New England, South Atlantic, and Gulf States, where they were near or slightly above the normal. To the westward of the Rocky Mountains the temperatures were likewise above the normal.

During the first few days of the last week of the month cool weather extended from the Missouri Valley southeastward to the Atlantic Coast. With only a slight interval of warmer weather following, a second cool wave appeared in the Northwest and moved rapidly eastward along the northern boundary with low temperatures and local frosts, reaching the Atlantic Coast shortly after the middle of the week. At the same time, another cool wave moved into the lower Missouri Valley with temperatures from 10 degrees to 20 degrees or more below the seasonal average and frosts occurred in many localities. Over the districts to the westward of the Rocky Mountains the weather generally was warmer than the average. In the South also temperature changes were moderate, but there was a tendency to cooler weather as the week advanced. At the close of the week there was a further fall in temperature over nearly all eastern districts and record breaking low temperatures for August occurred at many points. In the Northwest the weather was warmer and it continued warm in the far West.

The mean temperatures for the week were very generally the lowest for the summer over much of the great cereal and grass producing sections. To the westward of the Rocky Mountains they were above the normal, the greatest positive departures being about 10° as compared with negative departures of about the same value in the coldest districts to the eastward of the Rocky Mountains.

PRECIPITATION.

Generally stormy conditions prevailed over the eastern districts at the beginning of the month, and during the early part of the first decade heavy rains were general in the Lake region and over the Atlantic Coast States from the Carolinas northward to southern New England. High winds and heavy rains did considerable damage to crops over the Atlantic Coast States, while at points in the Lake region heavy rains caused much damage to property, notably at Erie, Pa., where, in addition to large property loss by flood, a score or more of persons were drowned. Rain continued locally at intervals over the districts from the Lake region and Ohio Valley eastward for several days. During the latter part of the decade local showers occurred at widely scattered points over the interior and southern districts, and from the Great Lakes and upper Ohio Valley eastward to the Atlantic, and the southern portions of the Rocky Mountain and Plains regions. The decade closed with showers quite generally from the middle Plains region and central Texas eastward to the Atlantic and thence northward to New England. Over most northern and western districts fair weather prevailed.

For the decade as a whole the rainfall was comparatively light throughout the country, save for generous falls in the Atlantic coast districts and comparatively heavy amounts in the region of the Great Lakes and in portions of Kansas, Oklahoma, and Missouri.

During the first few days of the week ending August 17 showers occurred over most eastern districts, with some heavy local falls in the Central Gulf States and Ohio Valley. By the middle of the week high winds and showers set in over the Florida Peninsula, and during the remainder of the week showers were quite general in the Gulf States, with heavy falls and considerable property damage in portions of Texas, due to the severe West Indian disturbance, the first of the season. At the close of the week showers were general also from the central Missouri and lower Ohio valleys eastward to New England, and there were local showers in the Northwestern States, but in the Central West and Southwest fair weather prevailed. East of the Rocky Mountains the rainfall for the week was generally sufficient for present needs, and in the central and east Gulf States the drouthy conditions were largely relieved by substantial showers. To the westward of the Rocky Mountains practically no rain occurred.

The tropical storm referred to above, a full description of which appears elsewhere in this REVIEW, made little progress during the first few days of the week ending August 24, and rain occurred quite generally over nearly all districts from the middle Plains States and central Texas eastward, with heavy falls in portions of the west Gulf States and the central Mississippi Valley. By the middle of the week the rain area had covered most eastern districts with large daily amounts in some sections, particularly in portions of the Ohio and middle Mississippi Valleys. By the end of the week the weather had generally cleared to the eastward of the Mississippi, while local rains were in evidence in the Northern and middle Plains States and upper Mississippi Valley. In portions of the central and southern Mississippi and lower Ohio valleys,

the total rainfall for the week was excessive, ranging from 4 to 8 inches or more, while in most districts to the eastward generous showers occurred, especially in the central Gulf States, where moisture was needed. The amounts for the week were light in the Middle Atlantic States and over the spring-wheat belt, while in extreme southern Texas, much of the Florida Peninsula, and to the westward of the Rocky Mountains practically no rain occurred.

In addition to the great loss of life and damage to property resulting from the high winds and torrential rains along the Texas coast, and to a considerable distance inland, serious flood damage occurred in the central Mississippi and lower Ohio valleys, especially at St. Louis, Mo., and vicinity.

No well-defined rain area crossed the country during the last week of the month, although considerable precipitation fell. Fairly general rains occurred over the Atlantic coast States near the middle of the week, and local heavy falls occurred in Texas. Toward the end of the week rains became rather general over the districts to the eastward of the Mississippi, but by the close the weather had cleared in nearly all parts of the country. Only light showers occurred in the districts between the Mississippi River and Rocky Mountains, except in Texas and portions of the immediate Mississippi Valley, while in the far West the week was practically rainless.

For the week as a whole the rainfall was generally light, except over much of Texas, portions of the middle Mississippi Valley, and most of the Atlantic coast districts, where generous amounts occurred.

GENERAL SUMMARY.

The weather for August, 1915, was characterized by almost continuously low temperatures over large portions of the great cereal and grass growing States, the accumulated daily deficiency since the middle of May exceeding that of any previous similar period in the past 40 years.

Rain fell over practically all portions of the country, except the western half of California, northeastern Nevada, and the northwestern portions of Oregon and Utah. The rainfall was heavy in portions of the west Gulf States, central Mississippi and lower Ohio valleys, portions of the Middle and South Atlantic States, and the central Florida Peninsula.

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Average accumulated departures for August, 1915.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.	°F.	Ins.	Ins.	Ins.	0-10		P. ct.	P. ct.
New England	66.1	−1.0	+ 6.3	5.23	+1.10	−1.10	6.3	+1.3	83	+ 1
Middle Atlantic	71.9	−0.9	+ 4.3	6.39	+1.90	+0.50	6.0	+0.9	78	+ 7
South Atlantic	78.9	−1.1	− 2.4	6.14	0.00	−4.00	6.1	+0.9	80	− 2
Florida Peninsula	83.2	+1.3	− 9.1	3.73	−3.20	−0.70	4.9	−0.3	75	− 4
East Gulf	80.0	+0.8	− 2.2	4.61	−0.30	−4.00	5.9	+0.7	78	+ 2
West Gulf	78.8	−2.2	− 7.6	8.76	+5.80	+4.00	5.8	+1.8	77	+ 2
Ohio Valley and Tennessee	70.6	−4.1	− 7.6	5.96	+2.50	−2.70	6.5	+2.0	80	+ 8
Lower Lakes	66.3	−3.3	− 5.3	4.67	+1.70	−0.80	6.2	+1.6	80	+ 9
Upper Lakes	62.7	−3.5	+ 2.3	3.74	+0.80	−1.50	5.3	+0.6	78	+ 3
North Dakota	65.4	−1.3	+10.0	1.48	−0.80	−1.10	2.3	−1.7	70	+ 6
Upper Mississippi Valley	67.2	−5.8	− 4.4	4.48	+1.20	+4.60	5.6	+1.4	78	+ 8
Missouri Valley	68.0	−5.8	− 8.4	3.44	−0.10	+7.70	4.8	+0.7	76	+ 9
Northern slope	66.7	0.0	+ 1.2	2.07	+0.80	+3.90	4.2	+0.3	65	+13
Middle slope	69.8	−5.4	−12.5	3.90	+1.50	+6.60	4.6	+0.8	73	+14
Southern slope	76.5	−2.6	−12.1	3.47	+1.30	+2.80	4.0	+0.1	60	+ 5
Southern plateau	77.0	−0.3	−15.8	0.62	−0.50	+1.50	2.6	−1.1	44	+ 2
Middle plateau	73.5	+1.9	− 1.5	0.18	−0.66	−0.60	1.9	−1.4	29	− 4
Northern plateau	76.0	+5.6	+14.5	0.07	−0.30	+0.30	2.5	+0.2	36	− 7
North Pacific	64.4	+3.4	+19.4	0.17	−1.40	−6.10	4.4	−0.2	73	+ 6
Middle Pacific	67.2	+2.3	+ 6.7	0.01	0.00	+4.70	2.9	−0.7	60	− 7
South Pacific	72.7	+2.2	+10.2	0.00	0.00	+3.90	1.8	−1.0	66	0

Maximum wind velocities, August, 1915.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mi/hr.				Mi/hr.	
Charlotte, N. C	29	52	w.	New York, N. Y.	4	64	se.
Columbus, Ohio	24	64	nw.	Norfolk, Va.	16	50	sw.
Del Rio, Tex	13	52	ne.	Point Reyes Light, Cal	3	52	nw.
Galveston, Tex	16	85	ne.	Do	5	50	nw.
Do	17	93	e.	Do	6	50	nw.
Houston, Tex	16	58	ne.	Do	7	54	nw.
Do	17	80	se.	Do	10	60	nw.
Jacksonville, Fla.	2	54	s.	Do	12	57	nw.
Mount Tamalpais, Cal	2	66	n.	Do	13	53	nw.
Do	3	69	n.	Do	31	53	nw
Do	5	55	nw.	Richmond, Va.	1	55	nw.
Do	6	64	nw.	San Antonio, Tex.	17	60	n.
Do	7	57	nw.	Sandy Hook, N.Y.	4	54	e.
Do	10	53	nw.	San Juan, P. R.	11	60	ne.
Do	12	52	nw.	Sand Key, Fla.	13	50	e.
Do	28	54	nw.	Do	14	60	se.
Do	29	63	nw.	Taylor, Tex	17	54	n.
Do	30	51	nw.				
Do	31	53	nw.				

WEATHER CONDITIONS ON THE NORTH ATLANTIC DURING AUGUST, 1914.

P. C. DAY, Climatologist and Chief of Division.

The data presented are for August, 1914, and comparison and study of the same should be in connection with those appearing in the REVIEW for that month. The accompanying chart (No. IX) shows for August, 1914, the averages of pressure, temperature, and the prevailing direction of the winds, together with the locations and courses of the more severe storms of the month.

For the month as a whole the distribution of the mean atmospheric pressure over the greater part of the ocean was similar to the average as shown on the Meteorological Chart of the North Atlantic Ocean for August. The Azores high was of normal intensity and position, although of greater area than usual. The center of the Icelandic low is not shown on account of lack of reports from that portion of the ocean, although it was probably not far from the normal position.

The wind and temperature conditions over the greater part of the ocean and adjacent land areas are greatly influenced by the relative positions and intensities of these so-called centers of action, and as the latter appear to have conformed closely to normal, the average winds and temperatures during the month were likewise not far from the normal.

The pressure was remarkably uniform throughout the month, and only three storms of considerable extent occurred, all of which appeared between August 21 and 27. On the 20th a low appeared near latitude 50° and longitude 50°, accompanied by moderate winds. By the 21st this had moved due east to longitude 35°, and increased in intensity. One vessel in the southeast quadrant reported a west-south-west wind of 56 miles an hour. and several other ships recorded velocities of from 40 to 48 miles. On the 22d this low was centered near latitude 54° and longitude 27°, having changed little in intensity, although a number of observations south of the center showed westerly winds of from 48 to 60 miles an hour, From the 22d to the 23d it moved about 5° in a northeasterly direction, and while the barometer had fallen somewhat since the preceding day, the winds had moderated in force, and by the 24th the storm had practically disappeared.

On the map of "Tracks of centers of Low Areas" (Chart III), published in the REVIEW for August, 1914, a storm track is shown beginning on the 15th at a point in southeastern Alberta. This low after moving in a southeasterly direction as far as Omaha, curved slightly toward the northeast, and after following an approximately easterly course, appeared off the coast of Newfoundland on August 23. On the 24th it had moved to latitude 52° and longitude 35°, having increased in intensity, as three vessels in its southwest quadrant each recorded northwest winds of 48 miles an hour. On the 25th it was centered at latitude 53° and longitude 20°, but was apparently weakening, as the barometer readings were from 29.18 to 29.44 inches, while the winds decreased in force. On the 26th traces of this low could be seen near Stornoway on the Scotland coast, but it had lost its force and was fast filling in.

Again the chart shows a storm that first appeared on the weather map in the eastern part of British Columbia on August 20. It crossed the path of the first track about 230 miles east of Miles City, and thence ran nearly parallel to it, keeping from 100 to 300 miles to the northward, appearing near the west coast of Newfoundland on the night of August 24. By the morning of the 25th it had moved in a northeasterly direction to latitude 52° and longitude 52°, but was of light intensity, with moderate winds. On the 26th it was centered near latitude 55° and longitude 40°, having increased in intensity, winds of from 40 to 48 miles an hour, accompanied by rain and hail, being reported. From this point it turned in a northeasterly direction and on the 27th it was near latitude 61° and longitude 27°, the barometer falling to 29.08 inches and the wind increasing somewhat.

This low probably proceeded toward Iceland, but as no reports were received from that part of the ocean it was impossible to indicate its further course. These two storms, both of the Alberta type, were accompanied by little severe weather, but their tracks are especially interesting on account of the long duration and uniformity of movement. While these storms first appeared on the map in western Canada, it is entirely possible that they may have originated in Alaska, as offshoots of the Aleutian low.

OCEAN TEMPERATURES.

The temperature over the ocean, for the month as a whole, differed but little from the normal. The departures were small and irregular, although they seem to show that along the fortieth meridian, from latitude 40° to 50°, the temperature was about 3° below the normal, while along the tenth meridian, west longitude, the departures averaged about +1.5°, and along the American coast they were small and not at all uniform. The departure at Eastport, Me., was +0.1°, Portland −2.1°, and Boston +1.5°. Between Cape May and Jacksonville they were more uniform, ranging from +0.7° at the former place to +1.9° at the latter, while at Key West it was +0.4°, and at Tampa +2.2°. The greatest monthly range within any 5-degree square was 20°; from 50° to 70°, and occurred in the square from latitude 45° to 50° and longitude 65° to 70°, where the water area is much less than the land. In mid-ocean, north of latitude 40°, the range was seldom over 7°, while south of that parallel it was less.

While it rained nearly every day over some portion of the trans-Atlantic steamer route, hail was recorded only on August 26, near latitude 46° and longitude 43°.

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data, as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Summary of temperature and precipitation by sections, August, 1915.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		Ins.	Ins.		Ins.		Ins.
Alabama	78.9	−0.7	Goodwater	105	1	Florence	49	31	5.07	+0.51	Cordova	10.56	Montgomery	1.10
Arizona	80.1	+0.7	Sentinel	120	19	Snowflake	28	30	1.27	−1.05	Carrs Ranch	4.19	Gila Bend	T.
Arkansas	74.7	−4.9	Hemp Wallace	102	8	Dutton	40	31	10.44	+7.37	Hardy	19.55	Huttig	3.14
California	74.2	+1.4	Indio	120	19	Cohnillo	25	5	0.06	−0.02	Julian	1.83	196 stations	0.00
Colorado	62.2	−3.1	2 stations	99	5†	Dillon	25	2†	2.32	+0.74	Burlington	8.73	Delta	T.
Florida	82.7	+1.4	4 stations	102	1†	De Land	63	21	6.92	−0.86	Bassenger (near)	20.70	Key West	0.92
Georgia	79.7	+0.4	Bainbridge	105	1	Gainsville	51	6	5.12	−0.48	Augusta	12.53	West Point	1.94
Hawaii (July)	74.4	......	2 stations	93	13†	2 stations	53	1†	5.77	....	Luakaha, Oahu	19.95	WaiopaeRanch, Maui	0.00
Idaho	70.3	+4.2	Glenns Ferry	111	10	Pierson	26	4	0.25	−0.31	Wallace	2.57	15 stations	0.00
Illinois	67.8	−6.1	4 stations	94	1†	Dakota	31	30	6.01	+2.65	St. Elmo	14.39	Riley	1.12
Indiana	68.0	−5.8	Rome	97	1	2 stations	35	31	6.41	+3.12	Connersville	12.95	Collegeville	1.17
Iowa	65.9	−5 9	6 stations	91	6†	Mason City	30	30	2.81	−0.87	Clinton	9.14	Cedar Rapids	0.41
Kansas	70.1	−7.0	Ellsworth	98	6	Jetmore	36	30	4.61	+1.48	Madison	10.82	Lawrence	1.72
Kentucky	71.3	−4.4	Earlington	100	1	2 stations	42	31	6.29	+2.94	Owensboro	11.03	Anchorage	4.00
Louisiana	80.8	−1.0	Angola	105	1	2 stations	51	31	6.78	+1.60	Merryville	17.38	Tallulah (near)	1.24
Maryland—Delaware	72.7	−0.7	Cambridge, Md	102	1	Oakland, Md	38	19	8.19	+3.52	Darlington, Md	12.56	Princess Anne, Md	2.66
Michigan	62.6	−3.7	Durand	94	2	Baraga	21	18†	3.79	+1.19	Grand Haven	8.02	Houghton	1.19
Minnesota	64.0	−2.7	2 stations	94	13	Roseau	23	26	1.91	−1.32	Fairmont (near)	5.63	2 stations	T.
Mississippi	79.2	−1.3	Porterville	104	2	5 stations	52	5†	4.74	+0.44	Hernando	11.25	Enterprise	1.09
Missouri	69.8	−6.5	Poplar Bluff	98	1	2 stations	37	30†	7.86	+4.15	Koshkonong	14.58	Macon	1.78
Montana	66.9	+2.8	Springbrook	102	31	Bowen	23	30	1.01	−0.14	Babb	3.70	3 stations	T.
Nebraska	67.2	−5.6	Culbertson	100	12	2 stations	32	29†	3.96	+1.15	Fremont	9.65	Hay Springs	0.73
Nevada	73.3	+1.6	Logan	112	20	Halleck	33	7	0.08	−0.31	Searchlight	0.99	14 stations	0.00
New England	65.9	−1.2	Woodstock, Vt	95	1	2 stations	30	28	5.61	+1.93	Turners Falls, Mass.	10.06	Enosburg Falls, Vt.	2.07
New Jersey	70.9	−1.1	2 stations	98	1	Charlotteburg	41	27	7.73	+2.89	Bridgeton	10.92	Asbury Park	4.02
New Mexico	68.3	−2.4	Artesia	103	13	Dulce	29	23†	2.14	−0.45	Valley	7.75	Fruitland	T.
New York	65.5	−1.7	Bedford Hills	94	24	Gabriels	29	27	5.71	+1.82	Boyds Corners	10.11	Hemlock	2.73
North Carolina	75.5	0.0	Mount Airy	102	1	Mount Mitchell	41	6†	6.49	+0.34	Mount Mitchell	16.40	Edinton	1.90
North Dakota	64.4	−1.1	McKinney	100	31	New Rockford	19	26	1.18	−1.14	Bismarck	3.44	University	0.07
Ohio	67.5	−4.2	Circleville	97	1	5 stations	34	31	4.52	+1.23	Hillsboro	9.90	Cleveland (2)	1.44
Oklahoma	74.1	−7.0	Eldorado	103	7	Bartlesville	38	31	6.42	+3.76	Heavener	13.64	Jefferson	1.46
Oregon	70.6	+5.0	Echo	108	29	Yonna	30	8	0.06	−0.48	Vistillas	0.78	33 stations	0.00
Pennsylvania	68.0	−1.7	Hamburg	99	1	West Bingham	34	18	6.71	+2.58	Lansford	14.44	Lock No. 4	1.92
Porto Rico	79.4	+0.3	2 stations	98	9†	Maricao	55	3†	8.28	+0.48	Rio Grande (El Verde).	32.97	San Juan	2.36
South Carolina	78.7	−0.1	2 stations	102	1	Mountain Rest	52	6	7.62	+1.26	Centenary	13.58	Newberry	3.72
South Dakota	65.3	−4.8	2 stations	99	31	Castlewood	32	30	2.19	−0.75	Rochford	7.90	Marston	0.46
Tennessee	73.6	−3.0	McMinnville	105	1	Erasmus	43	6	7.41	+4.07	Dyersburg	16.03	Copperhill	2.40
Texas	80.2	−2.9	2 stations	109	3†	Fort McKavett	40	31	6.05	+4.05	San Augustine	26.79	Riogrande	0.30
Utah	70.1	−0.3	2 stations	107	8†	Pine View	32	1	0.23	−0.77	Trout Creek Ranger.	2.00	17 stations	0.00
Virginia	73.3	−0.5	Catharpin	99	1	Burks Garden	40	23	5.88	+1.26	Danville	11.94	Cape Henry	1.19
Washington	69.9	+4.7	Hatton	108	29	Omak	33	4	0.12	−0.74	Deer Park	2.95	26 stations	0.00
West Virginia	69.4	−2.6	Romney	99	1	New Cumberland	36	1	4.84	+1.09	Martinsburg	8.36	Bluefield	2.44
Wisconsin	62.3	−4.8	Sheboygan	92	15	Deerskin Dam	25	30	3.45	+0.14	Watertown	7.19	Superior	1.61
Wyoming	61.1	−1.7	Worland	100	31	Norris (Y. N. P.)	21	5	1.59	+0.37	Kirwin	4.92	Hyattville	0.00

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations, making simultaneous observations at 8 a. m. and 8 p. m., daily, seventy-fifth meridian time, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)..............	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches).........	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes*, the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

The tipping-bucket mechanism is *dismounted* and removed when there is danger of snow or water freezing in the same. Table II records this condition by entering an asterisk (*).

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high area; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., seventy-fifth meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading and (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available, and all have been reduced to the 33-year interval 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading, and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction t_0–t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind-direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

Chart IX.—Average values of pressure, temperature, and prevailing wind direction, and storm tracks over the North Atlantic Ocean, *for the corresponding month of last year.*

[Charts H. C. F. 1–12, XLIII 92–103, accompany article "West Indian Hurricane of August, 1915," on p. 405, ffg.]

TABLE I.—*Climatological data for United States Weather Bureau stations, August, 1915.*

Districts and stations.	Elevation of instruments. Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Pressure. Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air. Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation. Total.	Departure from normal.	Days with 0.01 or more.	Wind. Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles.								0-10		
New England.							**66.1**	**− 1.0**										**83**	**5.23**	**+ 1.1**										**6.3**	......	....
Eastport	76	67	85	29.89	29.97	+0.01	58.2	− 1.5	81	12	65	46	27	51	27	54	52	82	2.68	− 0.6	12	4,976	s.	30	se.	23	6	5	20	7.6	......	....
Greenville	1,070	6	......	......	......	......	61.4	......	83	12	70	32	28	53	35	......	......	......	6.13	......	16	......	......	......	......	......	......	......	......	......	......	....
Portland, Me.	103	82	117	29.88	30.00	+ .02	63.8	− 2.4	83	16	71	46	28	57	25	59	56	81	5.87	+ 2.3	15	5,607	s.	34	nw.	17	10	8	13	6.1	......	....
Concord	288	70	79	29.67	29.97	− .01	65.8	− 0.8	86	14	75	40	28	56	30	......	......	......	6.26	+ 2.5	15	3,469	nw.	30	sw.	1	10	10	11	5.4	......	....
Burlington	404	11	48	29.54	29.96	− .01	65.2	− 0.9	83	16	74	41	27	56	29	......	......	......	2.88	− 1.1	16	5,966	s.	28	s.	4	4	11	16	6.7	......	....
Northfield	876	12	60	29.06	30.00	+ .02	62.5	− 0.4	85	1	73	23	28	52	34	58	56	84	4.55	+ 0.6	17	4,084	s.	26	s.	4	3	8	20	7.4	......	....
Boston	125	115	188	29.84	29.97	− .02	69.1	+ 0.2	89	16	76	51	27	62	23	63	60	78	5.63	+ 1.6	14	6,727	w.	31	e.	4	9	13	9	5.3	......	....
Nantucket	12	14	90	29.96	29.97	− .02	67.0	− 1.0	82	16	73	53	28	61	18	64	62	91	4.93	+ 1.9	10	9,673	sw.	42	ne.	3	7	10	14	6.1	......	....
Block Island	26	11	46	29.95	29.98	− .01	67.7	− 1.0	81	15	73	55	27	63	15	65	64	91	4.49	+ 1.0	11	11,008	sw.	44	ne.	3	8	10	13	6.5	......	....
Narragansett Pier	......	9	......	......	......	......	67.7	− 0.8	85	16	74	49	18	61	22	......	......	......	6.76	......	12	......	w.	......	......	......	18	4	9	......	......	....
Providence	160	215	251	29.80	29.97	− .02	68.6	− 2.4	88	13	76	50	27	61	23	64	61	80	4.48	+ 0.4	12	8,166	nw.	48	se.	4	11	10	10	5.4	......	....
Hartford	159	122	140	29.81	29.98	− .01	68.7	− 0.2	89	13	77	49	28	60	26	63	60	80	6.83	+ 2.3	13	4,740	s.	27	se.	4	4	17	10	6.4	......	....
New Haven	106	117	155	29.86	29.97	− .02	69.4	− 0.7	88	13	77	52	27	62	26	65	62	83	6.60	+ 1.6	13	6,173	nw.	39	e.	4	9	12	10	5.9	......	....
Middle Atlantic States.							**71.9**	**− 0.9**										**78**	**6.39**	**+ 1.9**										**6.0**	......	....
Albany	97	102	115	29.87	29.97	− .01	67.6	− 1.9	89	1	76	46	28	59	27	62	59	77	6.23	+ 2.3	17	4,187	s.	36	nw.	2	8	13	10	5.7	......	....
Binghamton	871	10	69	29.05	29.97	− .02	66.2	− 1.3	86	16	75	44	27	58	31	......	......	......	4.31	+ 1.0	17	3,043	e.	19	nw.	17	4	14	13	6.8	......	....
New York	314	414	454	29.64	29.97	− .03	70.4	− 1.8	87	16	77	55	18	64	21	64	61	75	5.37	+ 0.8	15	10,455	nw.	64	se.	4	3	16	12	6.8	......	....
Harrisburg	374	94	104	29.59	29.98	− .03	70.6	− 1.5	89	2	78	54	28	63	27	64	61	77	10.29	+ 6.0	16	4,165	w.	39	ne.	4	8	9	14	6.3	......	....
Philadelphia	117	123	190	29.86	29.98	− .02	73.1	− 0.7	96	1	80	58	18	66	23	66	63	76	6.84	+ 2.2	15	6,723	nw.	44	s.	4	6	11	14	6.2	......	....
Reading	325	81	98	29.63	29.98	......	70.6	......	92	1	78	53	18	63	22	64	61	77	8.44	+ 4.0	16	4,493	se.	38	ne.	4	6	10	15	6.6	......	....
Scranton	805	111	119	29.14	29.99	− .01	67.4	− 1.9	88	1	76	47	27	59	30	62	59	80	8.17	+ 3.9	18	4,183	sw.	26	sw.	7	4	11	16	7.1	......	....
Atlantic City	52	37	48	29.92	29.97	− .03	72.9	+ 0.3	89	16	79	54	18	67	24	68	66	80	4.98	+ 0.7	11	6,027	sw.	34	s.	4	8	11	12	6.1	......	....
Cape May	18	13	49	29.97	29.99	− .01	73.2	− 0.2	87	16	79	55	18	67	21	......	......	......	5.22	+ 1.0	14	5,994	s.	38	se.	4	11	14	6	5.1	......	....
Sandy Hook	22	10	57	29.94	29.96	......	71.4	......	88	16	77	58	18	66	19	67	65	84	6.72	......	12	10,380	ne.	54	e.	4	8	15	8	5.4	......	....
Trenton	190	159	183	29.76	29.96	......	70.9	......	94	1	79	53	18	63	23	65	62	79	6.22	+ 0.8	16	7,403	w.	48	sw.	4	5	11	15	6.8	......	....
Baltimore	123	100	113	29.85	29.97	− .04	74.2	− 0.5	96	1	82	56	18	67	22	67	64	75	9.93	+ 5.7	14	5,033	sw.	37	se.	4	6	15	10	5.7	......	....
Washington	112	62	85	29.85	29.96	− .05	74.0	− 0.5	97	1	83	54	19	65	26	67	64	78	7.00	+ 2.6	18	4,013	nw.	39	se.	4	8	17	6	5.4	......	....
Lynchburg	681	153	188	29.24	29.96	− .06	74.2	− 0.6	97	1	83	56	26	65	27	67	64	79	5.45	+ 1.2	14	4,454	w.	29	n.	1	7	17	7	5.9	......	....
Norfolk	91	170	205	29.89	29.98	− .02	78.0	+ 1.3	94	1	85	63	20	71	25	70	67	75	2.46	− 3.5	11	8,415	sw.	50	sw.	16	9	11	11	5.6	......	....
Richmond	144	11	52	29.83	29.98	− .03	76.2	− 1.3	98	1	85	57	19	68	30	69	66	74	7.34	+ 2.9	9	5,169	sw.	55	nw.	1	5	18	8	5.5	......	....
Wytheville	2,293	40	47	27.66	29.97	− .04	68.8	− 1.7	91	1	78	49	26	60	32	63	61	83	4.02	− 0.5	19	2,749	w.	24	w.	21	15	7	9	4.7	......	....
South Atlantic States.							**78.9**	**− 1.1**										**80**	**6.14**	**0.0**										**6.1**		
Asheville	2,255	70	84	27.70	29.99	− .03	70.4	− 0.1	89	1	80	52	23	61	30	64	62	85	4.26	− 0.5	18	4,372	se.	26	s.	2	8	13	10	6.0	......	....
Charlotte	773	153	161	29.16	29.98	− .04	76.0	− 0.6	95	1	84	61	19	68	21	68	66	79	4.59	− 1.0	13	6,801	sw.	52	w.	29	5	12	14	6.7	......	....
Hatteras	11	12	50	29.98	29.99	− .01	79.9	+ 1.7	89	16	85	66	20	75	17	74	72	81	3.30	− 2.5	13	9,163	sw.	41	w.	28	9	18	4	5.3	......	....
Manteo	12	4	46	......	......	......	78.6	......	93	16	87	56	20	71	......	......	......	......	2.94	− 3.0	8	......	sw.	......	......	......	20	8	3	......	......	....
Raleigh	376	103	110	29.59	29.97	− .04	77.4	+ 0.6	95	1	86	62	29	69	22	69	66	76	7.21	+ 1.3	13	5,285	sw.	48	w.	3	9	12	10	5.5	......	....
Wilmington	78	81	91	29.92	30.00	.00	79.2	+ 1.6	92	10	87	65	19	72	21	73	71	82	9.24	+ 2.7	17	4,807	sw.	29	sw.	3	7	16	8	5.6	......	....
Charleston	48	11	92	29.94	29.99	− .02	82.0	+ 1.7	96	25	89	69	31	75	20	75	73	79	5.40	− 1.6	15	6,683	s.	39	s.	3	3	16	12	6.2	......	....
Columbia, S. C.	351	41	57	29.61	29.98	− .03	79.3	− 0.2	96	1	88	65	31	70	25	71	69	80	4.56	− 2.2	14	4,546	s.	42	sw.	4	10	10	11	5.5	......	....
Augusta	180	89	97	29.80	29.99	− .02	79.4	+ 0.5	96	1	88	66	6	71	23	73	71	82	12.53	+ 7.0	14	3,656	se.	26	w.	29	8	4	19	6.6	......	....
Savannah	65	150	194	29.92	29.99	− .02	82.3	+ 2.9	96	24	91	68	5	74	23	75	74	84	9.44	+ 1.9	18	6,887	sw.	49	nw.	5	3	15	13	6.8	......	....
Jacksonville	43	209	245	29.95	30.00	− .01	82.8	+ 2.7	95	25	90	70	13	75	23	76	74	83	4.08	− 2.1	15	8,192	sw.	54	s.	2	4	16	11	6.5	......	....
Florida Peninsula.							**83.2**	**+ 1.3**										**75**	**3.73**	**− 3.2**										**4.9**		
Key West	22	10	64	29.95	29.97	−0.01	84.5	+ 0.7	91	21	90	72	14	79	13	77	74	72	0.92	− 3.8	8	6,688	se.	37	e.	14	13	13	5	4.5	......	....
Miami	25	71	79	29.97	30.00	......	82.6	+ 0.6	90	20	87	71	1	78	15	77	74	75	1.37	− 6.2	5	6,385	se.	32	e.	14	7	16	8	5.5	......	....
Sand Key	23	39	72	29.92	29.95	− .03	82.8	......	90	30	86	70	14	80	16	78	75	76	2.60	......	10	9,356	e.	60	se.	14	17	10	4	4.1	......	....
Tampa	35	79	96	29.96	29.99	− .01	82.6	+ 2.6	94	13	91	70	14	74	22	75	73	78	8.91	+ 0.3	17	4,396	ne.	36	se.	7	6	17	8	5.5	......	....
East Gulf States.							**80.0**	**+ 0.8**										**7.8**	**4.61**	**− 0.3**										**5.9**		
Atlanta	1,174	190	216	28.79	30.00	− .01	77.2	+ 1.1	96	1	86	57	31	69	24	69	67	80	4.92	+ 0.4	15	5,773	nw.	30	nw.	18	6	7	18	6.5	......	....
Macon	370	78	87	29.59	29.98	− .03	81.0	+ 2.8	97	1	91	64	31	71	26	72	69	76	2.94	− 1.3	14	3,727	s.	24	nw.	9	8	9	14	6.0	......	....
Thomasville	273	8	57	29.69	29.98	− .02	82.2	+ 1.2	98	27	93	64	31	72	27	74	72	83	2.76	− 2.3	12	3,265	sw.	28	e.	14	5	17	9	6.1	......	....
Pensacola	56	140	182	29.92	29.98	.00	81.2	+ 0.2	96	2	87	68	31	75	23	75	72	78	7.10	− 0.1	18	9,027	sw.	48	s.	16	5	13	13	6.5	......	....
Anniston	741	9	57	29.22	30.00	− .01	77.0	+ 0.6	97	1	87	56	31	67	32	......	......	......	8.61	+ 4.1	16	3,131	s.	27	nw.	29	9	17	5	4.8	......	....
Birmingham	700	11	48	29.24	29.99	.00	77.6	− 2.2	99	1	87	55	31	68	28	70	67	78	4.40	− 0.1	15	4,004	s.	32	s.	20	3	14	14	6.7	......	....
Mobile	57	125	161	29.91	29.97	− .01	81.4	+ 1.7	97	2	89	64	31	74	24	74	72	78	7.69	+ 0.9	15	6,822	sw.	38	nw.	6	8	16	7	5.4	......	....
Montgomery	223	100	112	29.74	29.98	− .01	81.2	+ 1.5	99	1	90	60	31	72	26	72	69	76	1.10	− 3.1	8	4,395	sw.	28	sw.	20	8	12	11	5.7	......	....
Meridian	375	85	93	29.58	29.96	− .02	79.4	+ 0.9	97	1	89	57	31	70	32	71	68	76	1.99	− 1.6	8	3,640	sw.	25	n.	1	7	17	7	5.6	......	....
Vicksburg	247	65	74	29.70	29.97	− .01	79.3	− 0.3	92	9	87	58	31	71	22	72	69	78	2.02	− 1.5	8	4,709	se.	28	w.	20	7	17	7	5.8	......	....
New Orleans	51	76	84	29.90	29.95	− .03	82.7	+ 1.7	96	3	90	69	31	75	23	75	72	77	7.22	+ 1.6	11	5,072	sw.	32	se.	16	9	16	6	5.4	......	....
West Gulf States.							**78.8**	**− 2.2**										**77**	**8.76**	**+ 5.8**										**5.8**		
Shreveport	249	77	93	29.68	29.94	− .03	78.4	− 3.0	98	6	86	59	31	70	26	72	69	80	8.60	+ 6.4	10	4,945	se.	30	e.	17	7	12	12	6.0	......	....
Bentonville	1,303	11	44	28.62	29.97	.00	69.8	− 6.7	89	16	79	45	31	60	34	......	......	......	9.66	+ 5.6	14	2,800	sw.	18	ne.	19	8	9	14	5.9	......	....
Fort Smith	457	79	94	29.48	29.95	− .02	75.3	− 4.1	92	6	83	51	31	67	26	69	66	77	9.64	+ 6.0	14	4,672	e.	39	w.	9	7	10	14	6.6	......	....
Little Rock	357	139	147	29.58	29.95	− .03	75.3	− 3.9	93	1	82	54	31	68	22	69	67	79	10.33	+ 6.7	15	5,270	e.	38	nw.	10	8	4	19	6.6	......	....
Brownsville	57	3	40	......	......	......	86.0	......	104	18	96	67	31	76	26	......	......	......	2.58	......	5	......	s.	20	s.	12	......	......	......	......	......	....
Corpus Christi	20	69	77	29.90	29.92	− .01	83.8	+ 1.7	100	18	89	67	31	78	21	76	74	80	1.20	− 1.1	6	9,619	se.	42	n.	16	8	13	10	5.9	......	....
Dallas	512	109	117	29.39	29.93	......	79.4	......	99	7	88	57	31	70	26	......	......	......	10.82	......	11	6,607	se.	49	ne.	17	8	15	8	5.5	......	....
Fort Worth	670	106	114	29.21	29.91	− .03	79.1	− 3.8	100	5	88	55	31	70	31	69	65	68	10.33	+ 8.5	9	7,057	ne.	44	ne.	17	4	11	16	6.5	......	....
Galveston	54	106	114	29.87	29.93	− .03	81.3	− 1.3	91	3	86	68	31	77	18	76	73	80	19.08	+14.1	11	9,490	s.	93	e.	17	8	11	12	5.8	......	....
Houston	138	111	121	29.75	29.89	......	81.8	− 1.1	98	2	90	64	31	73	25	......	......	......	15.43	......	17	6,187	s.	80	se.	17	13	12	6	4.7	......	....
Palestine	510	64	72	29.39	29.91	− .06	79.2	− 1.3	100	7	88	60	31	71	27	72	70	81	9.81	+ 7.6	11	4,709	s.	48	ne.	17	10	9	12	5.5	......	....
San Antonio	701	109	132	29.20	29.91	− .02	82.5	+ 0.5	101	2	93	58	31	72	29	71	67	68	3.90	+ 1.2	8	6,073	se.	60	n.	17	14	11	6	4.8	......	....
Taylor	582	55	63	29.34	29.94	− .01	80.4	− 1.3	100	6	90	57	31	71	29	......	......	......	5.03	+ 2.6	9	6,249	s.	54	n.	17	9	14	8	5.4	......	....

TABLE I.—*Climatological data for United States Weather Bureau stations, August, 1915*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level, feet.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sea level, reduced to mean of 24 hours.	Pressure: Departure from normal.	Temperature of the air: Mean max.+mean min.÷2.	Temperature of the air: Departure from normal.	Temperature of the air: Maximum.	Temperature of the air: Date.	Temperature of the air: Mean maximum.	Temperature of the air: Minimum.	Temperature of the air: Date.	Temperature of the air: Mean minimum.	Temperature of the air: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with 0.01 or more.	Wind: Total movement, miles.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles.								0-10		
Ohio Valley and Tennessee.							70.6	— 4.1										80	5.96	+ 2.5										6.5		
Chattanooga	762	189	213	29.20	30.00	0.00	75.0	— 1.5	94	1	83	59	6	67	27	68	66	81	9.09	+ 5.3	18	4,378	w.	32	s.	20	5	12	14	6.4	....	....
Knoxville	996	93	100	28.95	29.98	— .03	74.4	— 0.[illegible]	93	1	83	58	23	65	30	68	65	80	3.95	0.0	17	3,142	sw.	28	se.	11	4	9	18	7.1	....	....
Memphis	399	76	97	29.57	29.99	+ 0.1	75.9	— 3.[illegible]	93	15	83	55	31	69	20	69	67	79	10.60	+ 7.4	9	4,922	sw.	42	sw.	20	9	6	16	6.1	....	....
Nashville	546	168	191	29.41	29.99	— .01	74.1	— 3.[illegible]	96	1	83	51	31	66	29	67	64	78	6.03	+ 2.6	14	5,332	w.	42	s.	20	8	9	14	6.0	....	....
Lexington	989	193	230	28.93	29.98	— .03	69.5	— 5.1	89	1	77	46	31	62	22	....	....	....	6.03	+ 2.5	15	7,973	sw.	39	sw.	21	6	16	9	6.1	....	....
Louisville	525	219	255	29.41	29.99	— .01	71.2	— 5.3	91	1	79	47	31	63	25	64	61	76	4.65	+ 1.1	14	7,521	sw.	48	s.	20	6	9	16	7.0	....	....
Evansville	431	72	82	29.50	29.96	— .03	71.4	— 5.6	91	1	79	48	31	64	23	65	63	81	7.83	+ 4.6	15	4,499	ne.	32	s.	20	4	14	13	6.5	....	....
Indianapolis	822	194	230	29.10	29.97	— .03	67.5	— 6.1	88	16	75	44	31	60	26	61	58	77	5.25	+ 1.9	11	6,890	sw.	39	e.	20	6	10	15	6.7	....	....
Terre Haute	575	96	129	29.35	29.96	......	68.2	......	89	1	76	44	31	60	26	63	61	81	4.49	......	14	5,608	sw.	34	e.	20	2	17	12	7.3	....	....
Cincinnati	628	11	51	29.30	29.97	— .04	68.6	— 6.9	90	16	77	43	31	60	26	63	60	81	4.13	+ 0.8	14	4,272	sw.	22	sw.	16	6	9	16	6.8	....	....
Columbus	824	173	222	29.12	29.98	— .03	68.2	— 4.8	88	1	77	43	31	60	26	62	60	80	7.01	+ 3.8	17	6,240	sw.	64	nw.	24	8	15	8	5.5	....	....
Dayton	899	181	216	29.02	29.96	......	67.4	— 6.2	87	16	76	42	31	59	27	62	60	82	4.76	+ 1.8	13	6,056	sw.	36	e.	20	4	14	13	6.3	....	....
Pittsburgh	842	353	410	29.09	29.97	— .04	69.1	— 3.4	89	3	77	46	31	61	26	62	59	74	2.73	— 0.4	12	7,104	sw.	47	nw.	2	8	10	13	6.2	....	....
Elkins	1,940	41	50	27.99	29.99	— .03	66.8	— 1.6	89	2	76	45	19	58	30	61	59	84	6.21	+ 2.6	20	2,424	w.	16	w.	4	4	14	13	6.9	....	....
Parkersburg	638	77	84	29.35	30.00	— .01	69.8	— 3.5	91	1	78	48	31	61	27	64	61	81	4.78	+ 1.2	16	3,087	se.	19	w.	8	7	10	14	6.5	....	....
Lower Lake region.							66.3	— 3.3										80	4.67	+ 1.7										6.2		
Buffalo	767	247	280	29.14	29.96	—0.03	66.2	— 2.6	84	1	72	46	31	60	21	61	59	80	6.19	+ 3.2	12	9,704	sw.	45	nw.	8	6	14	11	6.0	....	....
Canton	448	10	61	29.49	29.96	......	64.5	— 3.3	85	11	73	37	27	56	36	....	....	....	5.66	+ 3.0	14	5,720	sw.	28	w.	25	11	10	10	5.1	....	....
Oswego	335	76	91	29.60	29.96	— .03	65.2	— 3.6	81	24	71	48	27	60	21	60	58	80	3.97	+ 1.3	13	6,268	se.	31	ne.	17	7	15	9	5.7	....	....
Rochester	523	97	113	29.42	29.98	— .01	67.0	— 1.3	85	1	74	49	31	60	23	60	57	76	4.34	+ 1.4	14	5,066	sw.	22	w.	25	6	13	12	6.2	....	....
Syracuse	597	97	113	29.35	29.99	.00	65.8	— 2.8	84	1	73	45	27	59	22	61	59	84	5.45	+ 2.1	16	6,339	s.	36	w.	8	3	15	13	6.9	....	....
Erie	714	130	166	29.20	29.96	— .05	67.6	— 2.3	86	3	74	51	31	61	22	62	59	78	9.28	+ 6.0	18	8,184	se.	36	se.	12	5	16	10	6.2	....	....
Cleveland	762	190	201	29.16	29.97	— .04	67.1	— 3.3	86	3	73	48	31	61	19	62	59	79	1.47	— 1.7	13	7,535	sw.	33	ne.	27	4	11	16	6.7	....	....
Sandusky	629	62	103	29.30	29.97	— .04	67.6	— 3.9	86	3	75	45	31	61	23	62	60	78	2.43	— 0.9	10	6,753	sw.	34	n.	17	7	6	18	6.7	....	....
Toledo	628	208	243	29.30	29.98	— .02	66.8	— 4.1	84	16	74	46	31	60	24	61	59	78	3.26	+ 0.6	13	8,375	sw.	40	nw.	7	8	10	13	5.8	....	....
Fort Wayne	856	113	124	29.07	29.99	......	65.6	— 5.5	84	1	73	43	31	58	27	62	60	85	4.12	......	12	5,422	sw.	24	ne.	17	8	8	15	6.5	....	....
Detroit	730	218	245	29.19	29.98	— .03	66.0	— 3.9	83	1	73	47	31	59	23	60	57	78	4.63	+ 1.9	13	7,307	e.	35	sw.	4	7	12	12	5.9	....	....
Upper Lake region.							62.7	— 3.5										78	3.74	+ 0.8										5.3		
Alpena	609	13	92	29.33	29.99	— .01	62.2	— 1.6	83	16	71	37	27	54	29	58	55	79	3.91	+ 0.6	10	7,444	nw.	46	e.	3	8	15	8	5.5	....	....
Escanaba	612	54	60	29.34	30.00	+ .01	60.2	— 4.3	82	13	68	35	30	52	26	55	52	77	3.12	— 0.5	14	6,775	n.	36	ne.	3	14	5	12	4.6	....	....
Grand Haven	632	54	92	29.30	29.97	— .02	63.2	— 4.0	80	1	71	41	31	56	27	59	56	79	8.02	+ 5.4	10	7,056	sw.	27	sw.	23	15	6	10	4.5	....	....
Grand Rapids	707	70	87	29.22	29.99	— .01	65.2	— 4.8	89	1	74	42	30	56	28	59	55	77	2.87	+ 0.3	10	3,911	ne.	22	nw.	16	14	6	11	5.0	....	....
Houghton	684	62	72	29.28	30.00	+ .03	60.6	— 2.7	83	14	70	37	30	52	29	....	....	....	1.19	— 1.7	9	5,617	w.	28	w.	25	9	11	11	5.4	....	....
Lansing	878	11	62	29.03	29.97	......	63.4	— 5.2	86	1	73	38	27	54	31	58	57	85	4.63	+ 2.0	13	3,290	ne.	20	nw.	16	9	9	13	5.8	....	....
Ludington	637	60	66	29.29	29.99	......	61.4	......	81	1	69	38	27	54	29	58	55	80	2.78	......	9	6,044	n.	26	n.	29	14	8	9	4.6	....	....
Marquette	734	77	111	29.24	30.04	+ .06	60.4	— 3.1	82	13	67	39	30	53	29	55	52	78	5.43	+ 2.6	13	6,260	w.	33	sw.	31	12	7	12	5.8	....	....
Port Huron	638	70	120	29.28	29.97	— .03	64.4	— 2.9	86	16	72	43	31	57	23	60	57	82	3.67	+ 1.0	13	6,677	ne.	29	nw.	30	8	16	7	5.6	....	....
Saginaw	641	48	82	29.29	29.98	......	64.0	......	85	1	73	41	31	55	29	58	55	78	5.28	+ 2.4	13	5,549	ne.	22	ne.	2	9	9	13	6.3	....	....
Sault Ste. Marie	614	11	61	29.32	30.01	+ .02	60.0	— 0.6	82	11	69	35	27	51	31	55	53	82	2.30	— 0.8	15	4,980	w.	38	nw.	25	8	7	16	6.2	....	....
Chicago	823	140	310	29.11	29.99	— .01	66.6	— 4.6	86	15	72	47	30	61	21	61	57	75	4.33	+ 1.4	12	7,871	ne.	34	ne.	20	10	9	12	5.5	....	....
Green Bay	617	109	144	29.33	29.99	.00	63.1	— 3.9	85	13	72	38	30	54	25	57	54	78	3.66	+ 0.6	13	7,411	ne.	42	ne.	3	11	10	10	6.0	....	....
Milwauke	681	119	133	29.26	29.99	— .01	64.4	— 4.3	85	15	71	42	30	58	25	58	55	73	2.38	— 0.4	10	6,722	ne.	28	n.	3	13	8	10	4.9	....	....
Duluth	1,133	11	47	28.83	30.04	+ .07	61.6	— 3.3	87	14	71	38	27	52	35	55	52	75	1.56	— 2.0	10	8,670	ne.	39	sw.	31	16	9	6	4.1	....	....
North Dakota.							65.4	— 1.3										70	1.48	— 0.8										2.3		
Moorhead	940	8	57	29.05	30.06	+ .10	65.2	— 0.7	89	14	79	36	26	52	40	58	54	75	1.05	— 2.0	4	4,355	s.	25	nw.	28	25	4	2	1.7	....	....
Bismarck	1,674	8	57	28.31	30.08	+ .14	65.2	— 2.9	92	31	78	37	24	52	39	58	54	74	3.44	+ 1.5	5	4,618	e.	29	nw.	20	20	7	4	3.4	....	....
Devils Lake	1,482	11	44	28.47	30.03	+ .11	64.6	— 0.5	90	31	79	31	26	50	43	56	50	66	0.90	— 1.9	6	5,990	sw.	32	n.	28	17	11	3	3.6	....	....
Williston	1,872	40	47	28.00	30.01	+ .08	66.8	— 1.1	93	31	81	39	2	52	40	56	50	63	0.54	— 0.8	4	4,253	se.	30	nw.	27	17	11	3	3.6	....	....
Upper Mississippi Valley.							67.2	— 5.8										78	4.48	+ 1.2										5.6		
Minneapolis	918	10	208	29.03	30.00	......	65.4	......	86	14	75	45	26	56	27	....	....	....	3.49	— 0.2	9	7,093	n.	36	n.	29	13	10	8	4.5	....	....
St. Paul	837	201	236	29.11	30.02	+ .05	65.4	— 4.1	86	14	75	42	30	56	30	....	....	....	3.98	+ 0.5	7	6,526	se.	36	e.	2	15	10	6	4.2	....	....
La Crosse	714	11	48	29.24	30.00	+ .02	64.8	— 5.2	85	16	75	35	30	54	31	....	....	....	3.83	+ 0.4	8	2,770	s.	16	n.	26	12	6	13	5.4	....	....
Madison	974	70	78	28.98	30.01	+ .02	63.8	— 5.8	85	1	72	43	30	56	25	58	55	77	4.39	+ 1.2	10	5,374	ne.	34	nw.	16	10	9	12	5.6	....	....
Charles City	1,015	10	49	28.95	30.02	+ .05	63.7	— 7.0	85	16	75	34	30	52	35	58	56	79	2.07	— 1.4	6	3,298	nw.	20	n.	29	10	16	5	4.9	....	....
Davenport	606	71	79	29.34	29.99	+ .01	67.2	— 5.8	88	16	76	40	30	58	26	60	57	75	1.77	— 1.9	10	4,262	e.	20	e.	18	14	8	9	4.9	....	....
Des Moines	861	84	97	29.10	30.00	+ .03	67.3	— 5.7	87	15	77	43	30	58	30	60	56	73	1.71	— 1.9	11	4,032	n.	32	se.	6	11	9	11	5.5	....	....
Dubuque	698	81	96	29.28	30.02	+ .04	65.6	— 6.4	87	7	75	40	30	56	30	59	55	75	2.84	— 0.2	10	3,589	nw.	20	n.	29	10	10	11	5.5	....	....
Keokuk	614	64	78	29.34	30.00	+ .02	68.6	— 6.0	88	16	78	43	31	60	29	62	59	76	1.43	— 1.8	10	4,063	ne.	21	w.	5	10	7	14	....	....	....
Cairo	356	87	93	29.57	29.94	— .05	72.6	— 4.4	91	16	80	50	31	66	23	67	66	84	10.28	+ 7.4	13	5,237	n.	44	se.	1	8	10	13	6.2	....	....
Peoria	609	11	45	29.34	30.00	+ .03	67.2	— 5.3	88	16	77	41	31	58	31	61	59	83	4.78	+ 1.8	8	3,614	ne.	22	n.	20	8	9	14	5.9	....	....
Springfield, Ill	644	10	91	29.30	29.97	— .02	68.4	— 5.6	89	16	77	46	31	60	24	62	59	77	6.21	+ 3.4	10	5,099	ne.	29	n.	20	6	10	15	6.7	....	....
Hannibal	534	74	109	29.41	29.98	.00	68.1	— 6.9	89	16	77	41	31	59	30	....	....	....	4.49	+ 1.1	12	4,835	n.	27	n.	20	7	9	15	6.5	....	....
St. Louis	567	265	303	29.36	29.96	— .03	70.4	— 6.8	92	16	78	52	31	63	21	65	62	81	11.43	+ 8.8	13	7,525	ne.	48	ne.	20	5	16	10	6.4	....	....
Missouri Valley.							68.0	— 5.8										76	3.44	— 0.1										4.8		
Columbia, Mo	781	11	84	29.14	29.97	.00	68.2	— 6.5	88	15	77	40	31	60	32	....	....	....	4.29	+ 1.2	14	4,349	ne.	26	n.	20	6	11	14	6.3	....	....
Kansas City	963	161	181	28.98	29.99	+ .02	70.1	— 5.7	88	16	78	47	30	63	26	63	59	74	4.46	— 0.3	12	6,794	n.	33	n.	29	7	15	9	5.7	....	....
St. Joseph	967	11	49	28.98	30.00	......	69.8	......	88	16	79	46	30	61	29	63	60	78	3.12	......	10	4,133	ne.	38	nw.	22	7	16	8	5.4	....	....
Springfield, Mo	1,324	98	104	28.60	29.99	+ .02	68.8	— 6.0	88	16	76	48	31	61	24	64	62	82	10.81	+ 6.5	14	5,527	nw.	32	nw.	22	11	10	10	4.9	....	....
Iola	984	11	50	28.95	29.98	+ .02	70.0	— 6.3	91	6	80	44	31	60	31	....	....	....	5.05	+ 1.6	13	3,562	ne.	20	nw.	8	10	13	8	4.6	....	....
Topeka	983	85	101	......	......	......	69.8	— 6.2	91	6	79	45	30	61	28	....	....	....	2.19	— 2.1	11	5,081	ne.	27	nw.	2	10	15	6	4.9	....	....
Drexel	1,299	10	53	28.65	30.03	......	66.2	......	85	7	76	40	30	56	29	61	58	82	5.80	......	11	4,898	ne.	28	se.	6	10	12	9	5.3	....	....
Lincoln	1,189	11	84	28.77	30.01	+ .06	67.9	— 6.4	89	6	78	47	30	59	30	62	60	81	5.57	+ 1.9	14	5,075	n.	38	sw.	2	11	11	9	4.7	....	....
Omaha	1,105	115	121	28.86	30.02	+ .06	68.4	— 6.0	87	1	78	44	30	58	25	61	58	74	3.06	— 0.6	13	4,605	nw.	31	nw.	29	16	7	8	4.5	....	....
Valentine	2,598	47	54	27.36	30.05	+ .11	66.4	— 4.9	89	5	78	42	24	54	36	59	54	72	0.89	— 1.9	7	5,116	e.	34	ne.	1	10	19	2	4.1	....	....
Sioux City	1,135	94	164	28.83	30.03	+ .08	66.2	— 6.4	89	6	77	38	30	54	33	60	56	75	1.79	— 1.2	10	6,139	n.	41	w.	22	16	8	7	4.1	....	....
Huron	1,306	59	74	28.68	30.06	+ .11	65.5	— 3.6	86	6	77	40	30	54	33	59	55	75	1.55	— 1.1	5	5,500	se.	37	nw.	28	15	7	9	4.5	....	....
Pierre	1,572	70	75	28.42	30.07	+ .13	68.0	— 5.1	96	31	79	46	24	57	36	60	55	68	0.55	— 1.5	3	4,730	se.	36	n.	28	15	12	4	3.5	....	....
Yankton	1,233	49	57	28.71	30.02	+ .07	66.2	— 6.6	89	6	77	40	30	55	31	....	....	....	1.11	— 2.0	6	3,892	e.	36	nw.	22	10	15	6	4.9	....	....

TABLE I.—*Climatological data for United States Weather Bureau stations, August, 1915*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Precipitation.			Wind.										
	Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Total.	Departure from normal.	Days with 0.01 or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0-10		
Northern Slope.							**66.7**	**0.0**										**65**	**2.07**	**+ 0.8**										**4.2**		
Havre	2,505	11	44	27.39	29.98	+0.07	70.0	+ 3.1	94	9	85	44	29	55	45	60	55	68	0.94	− 0.3	6	3,283	e.	34	sw.	9	27	2	2	2.6	......	....
Helena	4,110	87	114	25.87	29.98	+ .04	69.5	+ 3.4	90	31	83	49	26	56	36	56	48	54	0.59	− 0.1	5	5,276	sw.	39	sw.	5	13	17	1	4.2	......	....
Kalispell	2,962	11	34	26.94	29.92	− .01	69.1	+ 6.2	90	6	85	47	5	53	41	57	50	59	0.22	− 0.7	6	2,555	w.	23	sw.	14	25	6	0	2.3	......	....
Miles City	2,371	26	48	27.53	30.04	+ .11	72.2	+ 0.7	95	31	86	48	29	59	40	62	56	68	2.74	+ 1.7	7	2,966	ne.	32	e.	16	17	13	1	3.1	......	....
Rapid City	3,259	50	58	26.71	30.08	+ .15	65.5	− 3.3	93	31	76	44	30	54	40	57	52	69	3.35	+ 1.2	9	4,514	w.	28	n.	28	9	17	5	4.5	......	....
Cheyenne	6,088	84	101	24.16	30.05	+ .13	61.0	− 4.8	86	31	73	42	29	49	33	52	47	68	3.98	+ 2.5	11	5,679	w.	32	ne.	10	7	15	9	5.6	......	....
Lander	5,372	60	68	24.78	30.05	+ .13	64.4	− 1.3	94	31	80	44	26	49	41	51	42	53	1.04	+ 0.5	5	3,253	sw.	36	nw.	11	10	18	3	4.9	......	....
Sheridan	3,790	10	47	26.19	30.04	......	65.4	......	92	31	82	40	30	49	50	55	50	67	0.89	......	5	2,791	s.	25	ne.	19	8	15	8	5.2	......	....
Yellowstone Park	6,200	11	48	24.03	30.05	+ .12	60.8	− 0.1	86	30	76	39	26	45	40	49	43	63	1.53	+ 0.5	12	4,092	s.	39	s.	4	5	17	9	5.7	......	....
North Platte	2,821	11	51	27.18	30.07	+ .13	68.2	− 4.0	91	6	80	43	30	57	33	61	58	78	4.23	+ 1.8	12	3,532	se.	31	n.	1	12	12	7	4.3	......	....
Middle Slope.							**69.8**	**− 5.4**										**73**	**3.90**	**+ 1.5**										**4.6**		
Denver	5,291	129	172	24.86	30.06	+ .14	66.5	− 3.9	94	31	79	48	29	54	36	54	48	64	1.92	+ 0.6	12	4,883	sw.	36	n.	11	11	12	8	5.1	......	....
Pueblo	4,685	80	86	25.41	30.04	+ .13	67.9	− 4.2	91	31	80	47	30	56	42	55	49	60	3.27	+ 1.7	11	4,066	se.	42	nw.	6	14	15	2	3.5	......	....
Concordia	1,392	50	58	28.57	30.02	+ .07	70.1	− 6.4	90	6	80	43	30	61	29	63	60	77	1.99	− 0.8	12	4,076	nw.	26	nw.	28	6	12	13	6.0	......	....
Dodge	2,509	11	51	27.46	30.02	+ .09	70.0	− 6.5	91	6	81	43	30	59	34	63	60	78	6.16	+ 3.6	8	5,347	se.	42	ne.	13	13	14	4	4.3	......	....
Wichita	1,358	139	158	28.56	29.98	+ .03	71.0	− 6.5	89	6	80	46	30	62	26	64	61	77	4.81	+ 1.7	11	6,602	s.	47	n.	23	18	8	5	4.0	......	....
Oklahoma	1,214	10	47	28.72	29.97	+ .03	73.4	− 5.1	92	7	83	49	30	64	27	67	64	80	5.26	+ 2.1	15	7,294	n.	42	n.	2	12	14	5	4.5	......	....
Southern Slope.							**76.5**	**− 2.6**										**66**	**3.47**	**+ 1.3**										**4.0**		
Abilene	1,738	10	52	28.16	29.92	.00	77.8	− 3.4	97	8	89	48	31	67	35	66	61	63	2.04	+ 0.1	7	6,004	s.	36	nw.	12	11	12	8	4.9	......	....
Amarillo	3,676	10	49	26.33	30.00	+ .08	71.4	− 3.2	95	4	83	48	30	60	32	61	58	73	5.85	+ 3.0	10	6,232	s.	27	n.	14	20	8	3	3.2	......	....
Del Rio	944	64	71	28.93	29.90	.00	82.8	− 1.2	100	13	93	60	31	72	33	....	....		4.21	+ 1.7	9	6,322	se.	52	ne.	13	16	12	3	3.7	......	....
Roswell	3,566	75	85	26.41	29.95	+ .07	74.0	− 2.6	95	13	87	48	31	61	37	62	56	62	1.77	+ 0.3	11	4,527	e.	39	ne.	11	12	17	2	4.3	......	....
Southern Plateau.							**77.0**	**− 0.3**										**44**	**0.62**	**− 0.5**										**2.6**		
El Paso	3,762	110	133	26.20	29.88	+ .04	77.7	− 0.9	97	21	89	54	31	67	29	62	53	51	1.37	− 0.4	9	7,080	e.	46	ne.	24	16	9	6	4.0	......	....
Santa Fe	7,013	57	62	23.39	29.94	+ .05	65.4	− 1.6	83	4	77	49	26	54	31	53	46	57	1.02	− 1.3	9	4,629	se.	30	s.	5	10	18	3	4.6	......	....
Flagstaff	6,908	8	57	23.47	29.90	+ .06	63.2	+ 0.4	88	20	80	42	1	47	44	....	....		0.54	......	7	......	sw.	36	n.	10	12	18	1	......	......	....
Phoenix	1,108	76	81	28.66	29.78	− .01	89.1	+ 0.1	111	10	102	71	28	76	36	67	54	36	0.25	− 0.7	4	4,164	e.	42	ne.	29	25	3	3	2.5	......	....
Yuma	141	9	54	29.60	29.74	− .02	91.0	+ 0.9	116	19	108	67	1	74	46	72	62	45	0.41	+ 0.1	1	3,825	sw.	40	se.	26	29	1	1	0.7	......	....
Independence	3,910	11	42	25.93	29.83	+ .02	75.8	− 0.6	98	20	93	52	15	58	40	55	38	31	0.04	− 0.1	1	4,022	se.	33	se.	26	30	1	0	1.1	......	....
Middle Plateau.							**73.5**	**+ 1.9**										**29**	**0.18**	**− 0.6**										**1.9**		
Reno	4,532	74	81	25.48	29.88	+ .04	72.6	+ 5.6	100	29	91	47	1	54	45	51	34	32	T.	− 0.2	0	5,029	w.	31	w.	31	28	3	0	1.0	......	....
Tonapah	6,090	12	20	24.13	29.90	......	74.2	......	92	29	85	56	1	63	27	51	30	23	0.02	− 0.4	1	5,408	se.	26	nw.	24	23	8	0	1.7	......	....
Winnemucca	4,344	18	56	25.60	29.90	+ .02	72.0	+ 1.2	101	29	94	44	1	50	51	49	30	28	0.08	− 0.1	1	3,775	sw.	38	s.	31	26	3	2	1.5	......	....
Modena	5,479	10	43	24.67	29.90	+ .04	69.7	+ 1.1	93	20	88	45	24	52	43	48	28	29	0.46	− 1.4	3	7,624	w.	38	n.	30	26	5	0	1.7	......	....
Salt Lake City	4,360	147	189	25.62	29.89	− .02	78.0	+ 2.5	98	10	90	56	1	66	32	55	39	28	T.	− 0.8	0	5,600	se.	40	se.	16	17	14	0	2.5	......	....
Grand Junction	4,602	82	96	25.42	29.94	+ .04	75.0	− 1.1	95	4	89	54	17	61	36	53	40	35	0.51	− 0.5	7	5,875	e.	33	w.	15	19	10	2	2.9	......	....
Northern Plateau.							**76.0**	**+ 5.6**										**36**	**0.07**	**− 0.3**										**2.5**		
Baker	3,471	48	53	26.44	29.94	− .01	71.1	+ 6.2	97	29	88	49	31	54	43	54	40	39	T.	− 0.4	0	4,466	nw.	23	sw.	15	22	9	0	2.1	......	....
Boise	2.739	78	86	27.09	29.87	− .06	78.2	+ 6.4	98	17	94	56	1	62	39	57	42	32	T.	− 0.2	0	3,552	w.	27	w.	13	20	11	0	2.2	......	....
Lewiston	757	40	48	29.10	29.90	− .05	79.6	+ 6.1	105	10	97	57	28	62	45	....	....		0.19	− 0.2	1	2,224	e.	25	s.	16	26	4	1	1.8	......	....
Pocatello	4,477	46	54	25.50	29.91	− .01	72.4	+ 1.9	97	30	89	48	26	56	44	52	38	37	0.25	− 0.3	5	4,062	se.	26	sw.	24	10	18	3	4.4	......	....
Spokane	1,929	101	110	27.91	29.91	− .04	75.2	+ 7.3	97	10	91	52	4	60	41	57	44	40	T.	− 0.5	0	3,209	sw.	30	sw.	2	19	11	1	2.9	......	....
Walla Walla	1,000	57	65	28.82	29.87	− .09	79.3	+ 5.5	104	29	93	58	31	65	37	60	45	34	T.	− 0.4	0	3,008	s.	18	s.	2	27	4	0	1.6	......	....
North Pacific Coast Region.							**64.4**	**+ 3.4**										**73**	**0.17**	**− 0.4**										**4.4**		
North Head	211	11	56	29.82	30.04	+ .01	60.2	+ 2.3	77	20	64	53	27	57	19	58	56	89	0.12	− 0.4	3	9,331	nw.	40	se.	31	13	11	7	4.7	......	....
Port Crescent	259	8	53	29.77	30.04	+ .02	58.2	+ 2.0	88	20	67	43	27	49	35	....	....		0.16	− 0.5	2	3,309	n.	17	w.	16	12	13	6	4.7	......	....
Seattle	125	215	250	29.89	30.02	+ .02	66.8	+ 3.7	89	21	76	54	2	57	27	59	54	67	0.05	− 0.4	1	4,423	n.	34	sw.	30	12	11	8	4.4	......	....
Tacoma	213	113	120	29.79	30.01	− .01	66.6	+ 3.6	88	21	77	52	27	56	32	59	53	66	0.06	− 0.6	1	3,111	n.	19	sw.	5	8	20	3	4.6	......	....
Tatoosh Island	109	7	57	29.93	30.02	+ .02	57.4	+ 2.1	73	21	62	49	5	53	20	56	55	93	0.79	− 0.3	8	7,119	s.	38	s.	30	7	9	15	6.2	......	....
Portland, Oreg.	153	68	106	29.81	29.97	− .04	71.2	+ 5.3	97	28	83	54	4	60	35	61	55	61	0.01	− 0.6	1	3,786	nw.	18	nw.	19	15	11	5	3.4	......	....
Roseburg	510	9	57	29.44	29.98	− .02	70.7	+ 4.5	100	28	86	50	4	55	43	59	52	60	0.03	− 0.3	1	2,302	nw.	14	nw.	6	16	14	1	2.6	......	....
Middle Pacific Coast Region.							**67.2**	**+ 2.3**										**60**	**0.01**	**0.0**										**2.9**		
Eureka	62	73	89	29.96	30.03	+ .03	57.9	+ 2.1	66	11	62	49	4	54	14	55	54	88	0.00	− 0.1	0	3,734	n.	19	n.	2	4	13	14	6.5	......	....
Mt. Tamalpais	2,375	11	18	27.51	29.94	+ .01	71.7	+ 5.8	92	29	79	50	23	64	19	56	43	40	0.00	0.0	0	10,759	nw.	69	n.	3	29	2	0	0.4	......	....
Point Reyes Light	490	7	18	29.38	29.90	......	55.4	+ 0.9	75	28	59	49	2	52	22	....	....		0.00	0.0	0	18,808	nw.	60	nw.	10	8	4	19	6.8	......	....
Red Bluff	332	50	56	29.49	29.83	− .03	81.0	0.0	110	28	97	59	5	65	42	62	48	37	0.00	0.0	0	2,868	se.	13	n.	2	29	2	0	0.6	......	....
Sacramento	69	106	117	29.78	29.85	.00	75.0	+ 2.9	105	28	91	55	6	59	38	61	52	54	0.01	0.0	1	5,740	s.	19	s.	23	31	0	0	0.5	......	....
San Francisco	155	209	213	29.75	29.92	.00	61.3	+ 3.3	86	28	68	50	5	54	31	56	53	83	0.00	0.0	0	8,433	sw.	36	sw.	2	17	10	4	3.6	......	....
San Jose	141	12	110	29.80	29.94	......	67.8	+ 1.1	97	28	82	46	4	54	37	....	....		0.04	0.0	1	2,958	nw.	18	nw.	3	27	4	0	1.8	......	....
South Pacific Coast Region.							**72.7**	**+ 2.2**										**66**	**0.00**	**0.0**										**1.8**		
Fresno	327	89	98	29.49	29.83	+ .01	81.9	+ 0.7	109	29	90	58	25	65	39	61	46	36	0.00	0.0	0	5,918	nw.	22	nw.	31	31	0	0	0.1	......	....
Los Angeles	338	159	191	29.52	29.87	− .01	72.6	+ 4.0	99	30	83	57	26	62	33	64	60	73	0.00	0.0	0	3,691	sw.	21	e.	26	20	11	0	2.2	......	....
San Diego	87	62	70	29.78	29.87	− .02	69.5	+ 0.8	91	27	75	60	16	64	23	65	63	84	0.00	0.0	0	4,399	nw.	20	nw.	18	25	5	1	2.3	......	....
San Luis Obispo	201	32	40	29.72	29.93	− .01	66.8	+ 3.3	96	27	81	49	2	53	40	57	53	70	0.00	0.0	0	2,462	nw.	12	nw.	11	21	10	0	2.3	......	....
West Indies.																																
San Juan	82	8	54	29.87	29.95	− .02	81.3	......	90	23	86	72	11	77	14	....	....		2.36	− 5.0	13	9,687	e.	60	ne.	11	17	10	4	4.1	......	....
Panama.																																
Balboa Heights	116	7	97	29.71	29.83	......	80.4	......	91	12	86	72	9	74	17	76	76	93	15.24	+ 7.4	22	4,576	nw.	35	ne.	3	0	4	27	8.9	......	....
Colon	25	5	71	29.81	29.83	......	80.6	......	90	14	84	74	9	77	12	78	78	94	12.89	− 2.2	24	5,551	w.	26	w.	10	0	11	20	7.9	......	....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during August, 1915, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	24	1:10 a. m.	D. N. a. m.	1.51	1:15 a. m.	2:05 a. m.	0.02	0.20	0.34	0.37	0.40	0.46	0.60	0.80	0.91	0.98	1.05				
Albany, N. Y.	2	3:26 p. m.	3:53 p. m.	0.57	3:28 p. m.	3:43 p. m.	.01	.20	.45	.53											
	15	3:40 p. m.	4:40 p. m.	0.64	4:15 p. m.	4:35 p. m.	.04	.07	.20	.42	.58										
Alpena, Mich.	15			0.71														0.56			
Amarillo, Tex.	14	4:55 p. m.	D. N. p. m.	2.89	5:01 p. m.	6:15 p. m.	.01	.09	.12	.23	.41	.81	1.08	1.24	1.31	1.37	1.42	1.53	1.73		
	28	6:12 p. m.	6:27 p. m.	0.55	6:15 p. m.	6:26 p. m.	.01	.30	.52	.54											
Anniston, Ala.	10	9:27 p. m.	11:40 p. m.	1.68	9:33 p. m.	10:18 p. m.	.02	.05	.27	.54	.64	.73	1.00	1.15	1.21	1.28					
	18	11:09 a. m.	11:43 a. m.	0.56	11:19 a. m.	11:32 a. m.	.02	.09	.41	.53											
		7:58 p. m.	9:42 p. m.	2.34	8:06 p. m.	9:19 p. m.	.01	.06	.16	.30	.48	.54	.66	.85	1.15	1.45	1.68	2.05	2.28		
	20	8:30 p. m.	9:15 p. m.	0.69	8:43 p. m.	9:03 p. m.	.01	.36	.41	.48	.61										
Asheville, N. C.	3	5:50 p. m.	6:55 p. m.	1.02	6:11 p. m.	6:36 p. m.	.01	.07	.38	.72	.93	.99									
	10	5:25 p. m.	6:55 p. m.	0.60	5:42 p. m.	5:57 p. m.	.02	.20	.42	.55											
Atlanta, Ga.	14	3:38 p. m.	8:25 p. m.	1.47	4:26 p. m.	4:50 p. m.	.08	.05	.15	.28	.40	.55									
	19	2:09 p. m.	3:15 p. m.	0.97	2:12 p. m.	2:42 p. m.	.01	.08	.24	.45	.57	.76	.91								
	31	5:07 p. m.	7:05 p. m.	0.64	6:20 p. m.	6:50 p. m.	.01	.09	.21	.34	.45	.53	.61								
Atlantic City, N. J.	2–3	8:35 p. m.	D. N. a. m.	1.52	9:33 p. m.	10:29 p. m.	.07	.12	.29	.52	.71	.73	.76	.78	.80	.83	.99	1.17			
	3–4	1:25 p. m.	6:00 a. m.	1.54	4:30 a. m.	5:04 a. m.	.68	.08	.19	.27	.41	.65	.76	.80							
Augusta, Ga.	4	3:35 p. m.	7:40 p. m.	3.50	4:01 p. m.	5:32 p. m.	.03	.19	.53	.74	.86	.98	1.04	1.10	1.19	1.24	1.25	1.33	1.66	1.94	
					6:10 p. m.	6:47 p. m.	2.01	.11	.28	.50	.88	1.13	1.28	1.41	1.45						
	11	3:45 p. m.	6:30 p. m.	2.94	5:09 p. m.	6:06 p. m.	.70	.07	.16	.44	.62	.84	.97	1.06	1.43	1.86	2.01	2.16			
	16	10:05 a. m.	11:25 a. m.	1.25	10:40 a. m.	11:12 a. m.	.01	.10	.27	.69	.91	1.07	1.20	1.23							
	18	7:50 p. m.	10:45 p. m.	1.00	8:03 p. m.	8:21 p. m.	.06	.17	.50	.68	.73										
Baker, Oreg.	2, 13, 15, 16			T.														T.			
Baltimore, Md.	2	7:12 p. m.	8:05 p. m.	0.84	7:14 p. m.	7:41 p. m.	.01	.13	.28	.49	.67	.73	.79								
	3–4	10:00 p. m.	4:30 a. m.	2.80	12:52 a. m.	2:28 a. m.	.37	.10	.29	.48	.60	.76	.92	1.15	1.37	1.45	1.47	1.69	1.95	2.12	
	12	11:20 a. m.	2:20 p. m.	1.39	12:47 p. m.	1:06 p. m.	.22	.12	.49	.67	.77										
	21	3:40 p. m.	4:20 p. m.	0.63	3:40 p. m.	3:55 p. m.	.00	.25	.39	.52											
Bentonville, Ark.	18–20	12:20 a. m.	4:00 a. m.	5.48	12:02 p. m.	1:02 p. m.	2.06	.05	.10	.14	.24	.30	.38	.47	.53	.61	.68	.85			
Binghamton, N. Y.	4–6			1.32														.42			
Birmingham, Ala.	10–11	7:24 p. m.	D. N. a. m.	1.43	7:27 p. m.	8:00 p. m.	.01	.20	.46	.60	.78	.86	.93	.99							
	29	2:05 p. m.	3:18 p. m.	0.67	2:42 p. m.	3:02 p. m.	.13	.14	.40	.47	.53										
Bismarck, N. Dak.	20			0.30														.30			
Block Island, R. I.	4	10:30 a. m.	2:55 p. m.	1.40	11:30 a. m.	12:30 p. m.	.22	.09	.15	.20	.29	.32	.38	.46	.52	.64	.73	.85			
	22	8:03 a. m.	10:55 a. m.	1.01	10:09 a. m.	10:33 a. m.	.24	.07	.18	.38	.54	.70									
	25	4:35 a. m.	6:35 a. m.	0.85	4:48 a. m.	5:14 a. m.	.03	.23	.35	.37	.48	.60	.64								
Boise, Idaho	31			T.														T.			
Boston, Mass.	4–5	10:30 a. m.	6:00 p. m.	2.28	2:40 p. m.	4:00 p. m.	.65	.10	.16	.24	.32	.40	.45	.51	.60	.69	.77	.90	1.17		
Buffalo, N. Y.	3–4			2.55														*			
Burlington, Vt.	7	4:57 p. m.	5:40 p. m.	0.42	5:02 p. m.	5:19 p. m.	.01	.15	.24	.33	.40										
Cairo, Ill.	1	12:20 p. m.	4:55 p. m.	2.60	1:23 p. m.	1:46 p. m.	.19	.13	.27	.43	.64	.69									
					2:38 p. m.	3:03 p. m.	1.12	.13	.37	.68	.99	1.22									
	9	11:00 a. m.	2:50 p. m.	1.39	12:27 p. m.	12:52 p. m.	.31	.18	.29	.43	.66	.76	.79								
Canton, N. Y.	22	8:30 a. m.	6:20 p. m.	1.76	10:58 a. m.	11:21 a. m.	.30	.15	.23	.26	.42	.45									
Charles City, Iowa	16	5:08 p. m.	6:37 p. m.	0.77	5:11 p. m.	5:41 p. m.	.01	.11	.26	.37	.50	.56	.63								
Charleston, S. C.	31	2:35 p. m.	4:40 p. m.	0.58	2:54 p. m.	3:11 p. m.	.01	.11	.35	.50	.53										
Charlotte, N. C.	27	6:38 a. m.	8:48 a. m.	1.35	6:51 a. m.	7:11 a. m.	.03	.30	.59	1.06	1.16										
Chattanooga, Tenn.	17	2:06 p. m.	3:49 p. m.	0.70	2:34 p. m.	2:51 p. m.	.02	.10	.25	.46	.56										
	20	5:15 p. m.	6:25 p. m.	0.71	5:54 p. m.	6:09 p. m.	.04	.33	.52	.66											
Cheyenne, Wyo.	23	5:35 p. m.	8:35 p. m.	1.60	6:32 p. m.	7:11 p. m.	.42	.09	.17	.27	.37	.75	.98	1.04	1.09						
Chicago, Ill.	2–3	9:27 p. m.	11:50 a. m.	2.10	2:01 a. m.	2:31 a. m.	.59	.15	.28	.44	.52	.58	.73								
Cincinnati, Ohio	20–21			1.78														.33			
Cleveland, Ohio	20–21			0.59														.39			
Columbia, Mo.	7			0.61														.31			
Columbia, S. C.	27	11:20 a. m.	11:57 a. m.	0.54	11:20 a. m.	11:30 a. m.	.00	.22	.52												
Columbus, Ohio	11–12	4:25 p. m.	6:10 a. m.	3.53	7:39 p. m.	8:58 p. m.	.61	.10	.36	.68	.99	1.40	1.59	1.76	1.83	1.88	1.93	2.28	2.69		
	24	2:00 p. m.	2:55 p. m.	1.04	2:23 p. m.	2:36 p. m.	.01	.18	.58	.98											
Concord, N. H.	1	2:58 p. m.	5:18 p. m.	1.40	4:36 p. m.	4:56 p. m.	T.	.50	.93	1.19	1.32										
Concordia, Kans.	15			0.36														.35			
Corpus Christi, Tex.	29	8:13 p. m.	D. N. p. m.	0.96	8:15 p. m.	8:50 p. m.	.01	.08	.28	.42	.56	.69	.80	.86							
Davenport, Iowa	2–4			0.93														.32			
Dayton, Ohio	11	1:34 p. m.	1:55 p. m.	1.46	3:34 p. m.	3:54 p. m.	.50	.11	.24	.32	.42										
Del Rio, Tex.	27	3:35 p. m.	8:40 p. m.	1.57	3:41 p. m.	4:51 p. m.	.01	.21	.35	.39	.42	.47	.54	.62	.70	.76	.84	1.04	1.18		
Denver, Colo.	23			0.55														.44			
Des Moines, Iowa	6–7	D. N. p. m.	D. N. a. m.	0.68	10:47 p. m.	11:02 p. m.	.01	.17	.43	.59											
Detroit, Mich.	3	7:00 a. m.	1:26 p. m.	1.60	11:07 a. m.	11:30 a. m.	.68	.39	.50	.52	.60	.65									
	11–12	2:45 p. m.	6:45 a. m.	1.28	10:00 p. m.	10:22 p. m.	.26	.05	.22	.37	.52	.58									
Devils Lake, N. Dak.	22	4:41 p. m.	5:03 p. m.	0.41	4:46 p. m.	5:00 p. m.	.01	.19	.32	.40											
Dodge City, Kans.	1	11:20 p. m.	D. N. a. m.	1.17	11:23 p. m.	11:38 p. m.	T.	.25	.55	.67											
	8	5:30 p. m.	8:15 p. m.	1.92	5:41 p. m.	6:08 p. m.	.02	.23	.52	.86	1.20	1.36	1.44								
	13	1:20 p. m.	3:45 p. m.	2.43	1:29 p. m.	2:29 p. m.	.04	.27	.45	.64	.90	1.18	1.45	1.68	1.80	1.89	2.02	2.30			
Dubuque, Iowa	1	5:58 p. m.	7:59 p. m.	0.76	6:45 p. m.	7:07 p. m.	.07	.18	.37	.49	.55	.58									
Duluth, Minn.	23	1:13 p. m.	1:25 p. m.	0.28	1:13 p. m.	1:19 p. m.	.00	.26	.28												
Eastport, Me.	2	11:45 a. m.	4:00 p. m.	1.38	12:05 p. m.	12:47 p. m.	.05	.09	.13	.17	.24	.32	.50	.60	.74	.79					
Elkins, W. Va.	17	D. N. a. m.	D. N. a. m.	1.38	4:35 a. m.	5:06 a. m.	.56	.16	.30	.34	.47	.58	.79	.80							
El Paso, Tex.	2			0.56														.50			
Erie, Pa.	3–4	3:24 p. m.	D. N. a. m.	5.72	4:07 p. m.	4:35 p. m.	.37	.20	.52	.79	.79	.91	.94								
					5:18 p. m.	5:55 p. m.	1.60	.23	.52	.73	.86	.97	1.04	1.18	1.23						
					6:24 p. m.	6:53 p. m.	2.89	.10	.36	.60	.84	1.21	1.38								
	24	9:05 p. m.	10:10 p. m.	0.87	9:19 p. m.	9:49 p. m.	.01	.22	.45	.51	.57	.67	.75								
Escanaba, Mich.	13	2:25 p. m.	5:40 p. m.	0.60	2:28 p. m.	2:50 p. m.	.01	.06	.17	.28	.43	.46									
Eureka, Cal.	‡																				
Evansville, Ind.	17	1:25 p. m.	3:30 p. m.	1.82	1:37 p. m.	2:31 p. m.	.01	.18	.35	.44	.54	.79	1.04	1.17	1.32	1.55	1.69	1.77			
Flagstaff, Ariz.	26			0.21														*			
Fort Smith, Ark.	23–24	7:21 p. m.	D. N. a. m.	0.98	11:17 p. m.	11:44 p. m.	.04	.19	.38	.46	.62	.73	.77								
Fort Wayne, Ind.	2	2:45 p. m.	3:25 p. m.	0.35	2:48 p. m.	3:00 p. m.	.01	.20	.30	.33											
Fort Worth, Tex.	9–10	5:58 p. m.	5:35 a. m.	1.28	6:09 p. m.	6:55 p. m.	.01	.08	.17	.25	.47	.65	.66	.70	.79	.99	1.01				
	26–27	9:02 p. m.	1:05 a. m.	1.84	9:27 p. m.	10:08 p. m.	.06	.26	.56	.75	.98	1.16	1.25	1.43	1.47						
Fresno, Cal.	‡																				
Galveston, Tex.	3	1:02 p. m.	5:05 p. m.	2.05	1:04 p. m.	1:26 p. m.	.01	.31	.75	1.30	1.74	1.81									
	§16–17			13.65														*§			
	§ 19			1.71														*§			
Grand Haven, Mich.	2	D. N. a. m.	9:20 a. m.	4.18	2:08 a. m.	3:23 a. m.	.05	.08	.24	.28	.35	.45	.59	.79	1.02	1.13	1.29	1.52	2.02		
					8:19 a. m.	9:05 a. m.	3.03	.08	.20	.45	.69	.82	.86	1.00	1.08	1.15					
	3	D. N. a. m.	10:45 a. m.	1.80	6:15 a. m.	7:05 a. m.	.30	.13	.20	.25	.38	.44	.55	.66	.77	.81	.90				
	23	9:54 p. m.	D. N. p. m.	1.05	9:57 p. m.	10:27 p. m.	T.	.19	.41	.60	.80	.94	1.01								
Grand Junction, Colo.	7			0.25														.16			
Grand Rapids, Mich.	16	5:25 p. m.	7:45 p. m.	0.79	5:41 p. m.	5:58 p. m.	.01	.20	.36	.48	.53										

* Self-register not working. § Hurricane. ‡ No precipitation occurred during month.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during August, 1915, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Green Bay, Wis	16			0.60														0.44			
Hannibal, Mo	1	3:06 p. m.	5:10 p. m.	0.68	3:15 p. m.	3:32 p. m.	0.02	0.22	0.32	0.42	0.52										
	7	12 noon.	1:50 p. m.	0.83	1:16 p. m.	1:34 p. m.	.13	.26	.56	.61	.67										
	11	4:05 p. m.	4:56 p. m.	0.86	4:21 p. m.	4:45 p. m.	.04	.15	.43	.66	.74	0.80									
Harrisburg, Pa	21-22	5:50 p. m.	D. N. a. m.	4.22	7:07 p. m.	9:57 p. m.	.01	.05	.11	.12	.12	.14	0.21	0.45	0.75	1.02	1.51				
								1.83	1.92	2.11	2.13	2.34	2.40	2.49	2.50	2.50	2.53				
								2.53	2.55	2.62	2.66	2.76	2.84	2.89	2.95	2.98	3.00				
								3.02	3.07	3.29	3.36										
Hartford, Conn	2	4:35 p. m.	7:35 p. m.	1.23	5:00 p. m.	5:40 p. m.	.01	.12	.21	.26	.41	.51	.74	.85	.91						
	9	7:35 p. m.	8:20 p. m.	0.56	7:49 p. m.	7:58 p. m.	.01	.41	.55												
Hatteras, N. C	17	7:15 p. m.	D. N. p. m.	0.92	7:20 p. m.	7:50 p. m.	.01	.14	.36	.44	.49	.54	.62								
	28	6:04 p. m.	7:05 p. m.	0.73	6:08 p. m.	6:27 p. m.	.01	.20	.46	.60	.65										
Havre, Mont	3	7:20 p. m.	8:10 p. m.	0.44	7:28 p. m.	7:48 p. m.	T.	.08	.19	.25	.43										
Helena, Mont	4			0.17														.16			
Houghton, Mich	4			0.45														.13			
Houston, Tex	10	12:15 p. m.	1:20 p. m.	0.66	12:40 p. m.	1:07 p. m.	.05	.08	.30	.46	.51	.56	.60								
Do	16-17	11:27 a. m.	9:00 p. m.	7.52	9:00 p. m.		1.41	.05	.11	.19	.24	.28	.35	.42	.48	.54	.59				
								.63	.67	.72	.76	.81	.85	.92	.96	1.03	1.11				
								1.19	1.26	1.34	1.43	1.52	1.65	1.77	1.85	1.95	2.05				
								2.12	2.21	2.29	2.38	2.44	2.54	2.61	2.71	2.81	2.95				
						12:36 a. m.		3.12	3.19	3.24	3.29										
					3:33 a. m.	4:28 a. m.	5.61	.05	.15	.28	.43	.57	.73	.87	1.00	1.10	1.19	1.27			
Do	19	D. N. a. m.	6:15 a. m.	1.21	5:06 a. m.	5:38 a. m.	.56	.11	.21	.23	.32	.48	.58	.65							
Do	21	5:35 p. m.	6:32 p. m.	0.74	5:43 p. m.	6:11 p. m.	.01	.28	.50	.56	.62	.67	.72								
	28	6:02 a. m.	2:40 p. m.	3.88	6:05 a. m.	7:25 a. m.	.01	.28	.58	.76	1.07	1.24	1.33	1.35	1.41	1.81	2.20	2.67	3.18		
Huron, S. Dak	1			1.15														.63			
Independence, Cal	30			0.04														.03			
Indianapolis, Ind	10-11	7:15 p. m.	11:12 a. m.	1.95	12:16 a. m.	12:56 a. m.	.06	.07	.12	.16	.31	.43	.53	.58	.64						
Iola, Kans	9	3:30 a. m.	4:10 p. m.	2.45	12:11 p. m.	1:26 p. m.	.77	.07	.19	.34	.47	.57	.63	.68	.74	.79	.85	1.00	1.43		
Jacksonville, Fla	2-3			2.64														.33			
Kalispell, Mont	9			0.10														.10			
Kansas City, Mo	2	10:10 a. m.	11:07 a. m.	1.53	10:35 a. m.	11:01 a. m.	.02	.17	.35	.72	1.08	1.47	1.51								
	17	10:50 a. m.	11:35 a. m.	0.66	10:58 a. m.	11:13 a. m.	.01	.15	.50	.59											
	22	5:40 p. m.	7:50 p. m.	1.10	6:33 p. m.	7:09 p. m.	.10	.11	.25	.44	.69	.83	.88	.96	.98						
Keokuk, Iowa	16			0.52														.32			
Key West, Fla	6			0.35														.35			
Knoxville, Tenn	3	3:52 p. m.	4:08 p. m.	0.51	3:52 p. m.	3:59 p. m.	.00	.34	.49												
La Crosse, Wis	16	1:10 a. m.	D. N. a. m.	0.90	1:13 a. m.	1:28 a. m.	.01	.05	.28	.53											
Lander, Wyo	20	4:06 p. m.	5:36 p. m.	0.62	4:12 p. m.	4:26 p. m.	.01	.30	.45	.51											
Lansing, Mich	16	5:08 p. m.	D. N. p. m.	1.63	5:11 p. m.	5:27 p. m.	.01	.18	.60	1.00	1.04										
Lewiston, Idaho	16			0.19														.12			
Lexington, Ky	1	9:04 p. m.	10:15 p. m.	1.75	9:15 p. m.	9:40 p. m.	T.	.35	.75	1.05	1.35	1.65									
	2	7:15 p. m.	8:25 p. m.	1.09	7:17 p. m.	8:06 p. m.	.01	.15	.25	.43	.66	.77	.79	.79	.87	1.02	1.07				
Lincoln, Nebr	1	1:40 a. m.	2:45 a. m.	1.76	1:47 a. m.	2:32 a. m.	.03	.12	.30	.56	1.03	1.17	1.21	1.31	1.54	1.71					
Little Rock, Ark	9-10	11:50 p. m.	D. N. a. m.	2.71	11:53 p. m.	1:02 a. m.	.01	.15	.40	.47	.56	.93	1.01	1.25	1.38	1.57	1.84	2.38	2.60		
	18-20	1:00 p. m.	D. N. a. m.	4.21	4:08 p. m.	4:55 p. m.	.08	.08	.13	.16	.23	.38	.57	.75	.91	1.16	1.23				
	24	D. N. a. m.	D. N. a. m.	0.88	2:51 a. m.	3:19 a. m.	.15	.22	.26	.27	.46	.65	.70								
Los Angeles, Cal	‡																				
Louisville, Ky	16	11:58 a. m.	3:45 p. m.	1.09	12:28 p. m.	1:23 p. m.	.01	.15	.24	.30	.47	.53	.59	.67	.76	.87	.97	1.05			
Ludington, Mich	3	D. N. a. m.	D. N. p. m.	2.25	4:05 a. m.	4:34 a. m.	.08	.12	.17	.27	.42	.48	.55								
Lynchburg, Va	11-12	4:15 p. m.	D. N. a. m.	1.61	10:53 p. m.	11:37 p. m.	.34	.11	.33	.48	.51	.57	.58	.64	.76	.82					
Macon, Ga	18	12:55 p. m.	4:50 p. m.	0.69	1:06 p. m.	1:21 p. m.	.01	.19	.38	.58											
Madison, Wis	1-3			3.07														.66			
Marquette, Mich	3-4			3.84														.55			
Memphis, Tenn	18-19	6:38 p. m.	D. N. a. m.	2.30	1:38 a. m.	2:57 a. m.	.38	.15	.29	.53	.71	.80	.88	.94	1.00	1.13	1.17	1.38	1.76		
	23	3:07 p. m.	5:38 p. m.	1.90	3:17 p. m.	4:18 p. m.	.08	.40	.60	.68	.84	.91	.93	.94	.96	1.07	1.13	1.61	1.77		
	26	3:40 p. m.	6:12 p. m.	0.96	3:47 p. m.	3:58 p. m.	.01	.10	.48	.58											
Meridian, Miss	1	5:40 p. m.	6:12 p. m.	0.52	5:45 p. m.	6:04 p. m.	.01	.25	.39	.46	.51										
	10	6:05 p. m.	7:20 p. m.	0.79	6:36 p. m.	7:01 p. m.	.01	.15	.34	.48	.68	.75									
Miami, Fla	31			0.43														.26			
Milwaukee, Wis	1-2			0.93														.49			
Minneapolis, Minn	12	3:00 p. m.	3:30 p. m.	0.65	3:11 p. m.	3:26 p. m.	.01	.18	.53	.64											
Mobile, Ala	3	2:47 p. m.	4:35 p. m.	0.68	2:58 p. m.	3:27 p. m.	.03	.39	.48	.52	.60	.65									
	4	4:08 p. m.	5:50 p. m.	1.04	4:25 p. m.	5:00 p. m.	.07	.11	.42	.60	.64	.69	.72	.80							
	11	8:45 a. m.	4:25 p. m.	1.81	9:27 a. m.	10:23 a. m.	.05	.22	.51	.73	.81	.83	.85	.87	.94	1.11	1.24	1.34			
	21	D. N. a. m.	7:35 a. m.	2.28	2:32 a. m.	4:42 a. m.	.01	.05	.06	.29	.62	.80	.81	.87	.89	.96	.98				
								1.01	1.06	1.07	1.11	1.24	1.41	1.56	1.58	1.58	1.66				
								1.79	1.81	1.88	1.91	1.97	2.04								
Modena, Utah	26			0.32														.19			
Montgomery, Ala	21			0.38														.38			
Moorhead, Minn	22			0.53														.21			
Mount Tamalpais, Cal	‡																				
Nantucket, Mass	2	11:12 a. m.	4:25 p. m.	1.90	1:48 p. m.	2:23 p. m.	.49	.10	.22	.39	.62	.83	.92	.99							
	30	10:25 a. m.	2:45 p. m.	1.02	12:45 p. m.	1:05 p. m.	.23	.20	.34	.47	.55										
Nashville, Tenn	9	5:10 p. m.	6:05 p. m.	0.66	5:14 p. m.	5:25 p. m.	.01	.25	.56	.61											
	18	D. N. a. m.	4:30 p. m.	1.79	1:05 p. m.	1:36 p. m.	1.11	.07	.16	.28	.32	.40	.50	.53							
New Haven, Conn	4	D. N. a. m.	12:30 p. m.	3.11	9:23 a. m.	10:53 a. m.	.70	.05	.18	.29	.39	.50	.60	.72	.81	.92	1.06	1.33	1.90	2.07	
New Orleans, La	11	8:03 a. m.	9:40 a. m.	1.12	8:07 a. m.	8:28 a. m.	.02	.06	.46	.81	.94	.95									
	.....	10:05 a. m.	5:25 p. m.	1.21	10:31 a. m.	11:30 a. m.	.04	.16	.34	.38	.41	.46	.55	.63	.68	.72	.78	1.07			
	21	12:32 p. m.	2:15 p. m.	2.18	12:32 p. m.	1:15 p. m.	.00	.07	.31	.49	.77	1.12	1.45	1.82	2.09	2.16					
New York, N. Y	3-4	8:38 p. m.	10:10 a. m.	2.08	6:59 a. m.	7:29 a. m.	.80	.05	.17	.29	.38	.47	.54								
Norfolk, Va	1	8:03 p. m.	9:15 p. m.	0.55	8:10 p. m.	8:30 p. m.	.01	.12	.22	.36	.44										
Northfield, Vt	1	7:51 p. m.	8:45 p. m.	1.22	8:05 p. m.	8:28 p. m.	.06	.09	.29	.64	1.01	1.11									
North Head, Wash	31			0.06														.04			
North Platte, Nebr	6-7	9:48 p. m.	D. N. a. m.	0.62	10:05 p. m.	10:30 p. m.	.03	.10	.26	.37	.44	.50									
	17	6:45 p. m.	7:48 p. m.	0.65	6:48 p. m.	7:13 p. m.	.01	.11	.28	.40	.51	.57									
Oklahoma, Okla	8-9	11:58 p. m.	6:43 a. m.	1.83	12:03 a. m.	12:28 a. m.	.01	.10	.25	.67	.95	1.07									
Omaha, Nebr	17			0.90														.29			
Oswego, N. Y	21			0.96														.44			
Palestine, Tex	2	12:40 p. m.	4:35 p. m.	0.69	12:54 p. m.	1:20 p. m.	.01	.09	.17	.35	.49	.61	.63								
	25	11:35 a. m.	1:25 p. m.	1.08	12:37 p. m.	1:03 p. m.	.21	.15	.26	.57	.77	.86	.88								
	28	2:38 p. m.	3:20 p. m.	1.02	2:53 p. m.	3:13 p. m.	.08	.13	.34	.63	.93										
Parkersburg, W. Va	8	3:46 p. m.	6:08 p. m.	1.25	4:18 p. m.	5:06 p. m.	.10	.08	.26	.41	.54	.62	.66	.76	.95	1.01	1.04				
Pensacola, Fla	23	11:05 a. m.	12 m.	0.71	11:18 a. m.	11:34 a. m.	.01	.05	.30	.66	.68										
	25	1:55 p. m.	3:00 p. m.	1.45	2:07 p. m.	2:24 p. m.	.04	.39	.97	1.27	1.30										
	29	5:55 a. m.	8:15 a. m.	0.72	7:15 a. m.	7:41 a. m.	.02	.05	.10	.32	.55	.66	.69								
Peoria, Ill	2	7:40 p. m.	D. N. p. m.	2.17	8:41 p. m.	9:47 p. m.	.27	.13	.30	.53	.80	1.09	1.30	1.47	1.56	1.60	1.64	1.79	1.89		
Philadelphia, Pa	3-4	9:30 a. m.	7:05 a. m.	2.75	2:20 a. m.	3:04 a. m.	.26	.09	.15	.19	.22	.24	.30	.49	.69	.79					

‡ No precipitation occurred during month.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during August, 1915, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Phoenix, Ariz.	25			0.19														0.16			
Pierre, S. Dak.	1			0.40														.21			
Pittsburgh, Pa.	2	12:25 p.m.	2:55 p.m.	1.01	1:22 p.m.	2:07 p.m.	0.02	0.18	0.41	0.49	0.55	0.63	0.73	0.78	0.85	0.90					
	8	6:55 a.m.	8:45 a.m.	0.66	7:56 a.m.	8:10 a.m.	.10	.17	.38	.50											
Pocatello, Idaho	23			0.15														.14			
Point Reyes Light, Cal.	‡																				
Port Huron, Mich.	3	7:02 a.m.	2:30 p.m.	0.96	12:58 p.m.	1:15 p.m.	.42	.09	.23	.40	.46										
Portland, Me.	10	11:23 a.m.	11:41 a.m.	0.56	11:23 a.m.	11:33 a.m.	.00	.29	.53												
Portland, Oreg.	31			0.01														.01			
Providence, R. I.	4			1.30														.47			
Pueblo, Colo.	23	4:24 p.m.	7:12 p.m.	0.95	4:35 p.m.	4:54 p.m.	.01	.08	.27	.59	.67										
Raleigh, N. C.	3	8:32 a.m.	12:34 p.m.	1.34	10:40 a.m.	12:29 p.m.	.20	.06	.17	.33	.46	.52	.67	.89	1.01	1.04	1.11				
		5:35 p.m.	10:50 p.m.	3.37	8:43 p.m.	10:00 p.m.	.44	.14	.27	.28	.44	.51	.58	.59	.80	1.10	1.37	1.80	2.81		
Rapid City, S. Dak.	15	2:12 p.m.	4:40 p.m.	1.05	2:24 p.m.	3:09 p.m.	.01	.08	.18	.23	.35	.50	.60	.80	.93	.99					
	19	6:42 p.m.	8:00 p.m.	1.23	7:11 p.m.	7:43 p.m.	.21	.15	.37	.46	.60	.83	.92	.99							
Reading, Pa.	5–6	7:20 p.m.	3:10 a.m.	1.64	8:50 p.m.	9:44 p.m.	.11	.17	.27	.38	.44	.57	.72	.81	.91	1.04	1.13	1.24			
Red Bluff, Cal.	‡																				
Reno, Nev.	24			T.														T.			
Richmond, Va.	1	3:38 p.m.	D. N. p.m.	2.39	3:48 p.m.	4:46 p.m.	.05	.23	.57	1.02	1.22	1.31	1.39	1.54	1.62	1.67	1.72	1.83			
	3–4	5:12 p.m.	D. N. a.m.	3.14	6:46 p.m.	7:36 p.m.	.23	.08	.22	.33	.53	.74	.77	.82	.97	1.11	1.17				
					7:36 p.m.	8:26 p.m.		1.20	1.27	1.35	1.51	1.57	1.58	1.61	1.65	1.67	1.70				
					8:26 p.m.	8:56 p.m.		1.74	1.99	2.08	2.17	2.28	2.39								
Rochester, N. Y.	8	1:00 p.m.	2:44 p.m.	0.85	1:20 p.m.	1:50 p.m.	.04	.08	.19	.32	.37	.65	.71								
Roseburg, Oreg.	30			0.03														.03			
Roswell, N. Mex.	14	3:58 p.m.	4:47 p.m.	0.48	4:05 p.m.	4:25 p.m.	.01	.08	.21	.38	.45	.46									
Sacramento, Cal.	31			0.01														T.			
Saginaw, Mich.	6	5:31 p.m.	6:28 p.m.	0.49	5:34 p.m.	5:50 p.m.	.02	.17	.38	.45	.47										
St. Joseph, Mo.	22	5:05 p.m.	6:40 p.m.	0.73	5:29 p.m.	5:57 p.m.	.05	.20	.32	.43	.52	.57	.61								
St. Louis, Mo.	2	7:40 p.m.	9:05 p.m.	0.68	8:11 p.m.	8:33 p.m.	.08	.17	.32	.44	.50	.54									
	17	1:08 p.m.	5:20 p.m.	1.48	1:14 p.m.	1:38 p.m.	.01	.17	.42	.57	.73	.86									
St. Paul, Minn.	16	1:51 p.m.	3:33 p.m.	1.17	2:28 p.m.	3:15 p.m.	.12	.15	.32	.48	.61	.73	.79	.86	.92	.98	1.02				
Salt Lake City, Utah	5			T.														T.			
San Antonio, Tex.	10	11:38 a.m.	1:00 p.m.	0.62	11:40 a.m.	12:03 p.m.	.01	.13	.28	.43	.55	.57									
	28	12:30 a.m.	7:40 a.m.	1.89	2:03 a.m.	3:19 a.m.	.32	.09	.17	.23	.32	.38	.50	.59	.62	.64	.74	.99	1.23		
San Diego, Cal.	‡																				
Sand Key, Fla.	27	3:06 p.m.	3:45 p.m.	0.58	3:10 p.m.	3:25 p.m.	.01	.21	.38	.51											
Sandusky, Ohio	11			0.79														.41			
San Francisco, Cal.	‡																				
San Jose, Cal.	*																				
San Luis Obispo, Cal.	‡																				
Santa Fe, N. Mex.	7			0.42														.17			
Sault Ste. Marie, Mich.	23			0.35														.22			
Savannah, Ga.	8	12:45 p.m.	2:30 p.m.	1.16	12:47 p.m.	1:32 p.m.	.01	.10	.12	.37	.63	.82	.91	.95	1.02	1.08					
	11	3:09 p.m.	5:30 p.m.	1.87	3:32 p.m.	4:45 p.m.	.02	.06	.12	.16	.28	.39	.42	.42	.55	.57	.66	1.19	1.78		
	18	4:35 p.m.	6:33 p.m.	1.87	5:16 p.m.	6:16 p.m.	.26	.20	.36	.46	.67	.84	1.04	1.06	1.10	1.20	1.25	1.57			
	27	4:36 p.m.	5:25 p.m.	0.61	4:36 p.m.	4:50 p.m.	.00	.25	.47	.60											
	31	3:42 p.m.	6:20 p.m.	0.96	4:05 p.m.	4:40 p.m.	.10	.08	.26	.41	.49	.54	.61	.66							
Scranton, Pa.	16	2:53 p.m.	4:17 p.m.	1.46	3:06 p.m.	3:38 p.m.	.01	.33	.45	.52	.80	1.04	1.32	1.42							
	21–22	7:57 p.m.	D. N. a.m.	1.91	10:00 p.m.	10:18 p.m.	.01	.26	.40	.56	.65										
					2:07 a.m.	2:36 a.m.	1.20	.09	.29	.37	.45	.51	.62								
Seattle, Wash.	31			0.05														.04			
Sheridan, Wyo.	18			0.42														.27			
Shreveport, La.	14	5:50 p.m.	9:15 p.m.	1.17	6:44 p.m.	7:22 p.m.	.10	.09	.25	.36	.51	.62	.73	.82	.86						
	17–18	5:05 a.m.	7:30 p.m.	3.55	12:25 p.m.	12:56 p.m.	2.15	.07	.09	.15	.26	.48	.60	.64							
Sioux City, Iowa	17			0.57														.24			
Spokane, Wash.	3, 6, 7, 11, 20, 23, 26, 30			T.														T.			
Springfield, Ill.	1	5:20 p.m.	5:47 p.m.	0.60	5:24 p.m.	5:35 p.m.	.01	.34	.55	.58											
Springfield, Mo.	2	2:45 p.m.	3:19 p.m.	0.67	2:49 p.m.	3:07 p.m.	.01	.29	.47	.57	.65										
	17–18	7:35 p.m.	D. N. a.m.	1.96	7:49 p.m.	8:54 p.m.	.01	.21	.37	.62	.85	1.09	1.20	1.31	1.34	1.42	1.51	1.62	1.76		
	23	7:08 a.m.	1:15 p.m.	1.76	7:08 a.m.	8:15 a.m.	.00	.31	.40	.49	.52	.55	.61	.76	.79	.86	.93	1.01	1.25		
Syracuse, N. Y.	21	7:55 a.m.	6:00 p.m.	0.76	5:16 p.m.	5:31 p.m.	.31	.18	.32	.42											
Tacoma, Wash.	31			0.06														.05			
Tampa, Fla.	1–2	8:00 p.m.	12:40 p.m.	5.00	2:25 a.m.	4:03 a.m.	.66	.20	.33	.42	.54	.65	.70	.74	.75	.80	.93	1.26	2.40	2.88	
	8	2:05 p.m.	3:13 p.m.	1.59	2:09 p.m.	2:53 p.m.	.01	.13	.29	.55	.92	1.12	1.25	1.38	1.50	1.55					
	29	6:58 p.m.	7:55 p.m.	0.65	7:02 p.m.	7:16 p.m.	.01	.20	.47	.61											
Tatoosh Island, Wash.	30			0.26														.17			
Taylor, Tex.	28	8:01 a.m.	12:10 p.m.	1.89	8:01 a.m.	8:37 a.m.	.00	.26	.50	.65	.94	1.16	1.31	1.37	1.40						
Terre Haute, Ind.	11			1.50														.65			
Thomasville, Ga.	15	1:15 p.m.	2:50 p.m.	0.96	1:34 p.m.	2:00 p.m.	.01	.19	.53	.71	.74	.86	.87								
Toledo, Ohio	3	6:18 a.m.	11:38 a.m.	1.31	10:33 a.m.	10:50 a.m.	.79	.05	.19	.35	.41										
Tonopah, Nev.	31			0.02														.01			
Topeka, Kans.	17	3:48 p.m.	4:17 p.m.	0.48	3:55 p.m.	4:11 p.m.	.01	.14	.30	.42	.46										
Valentine, Nebr.	16			0.21														.21			
Vicksburg, Miss.	29	12:40 p.m.	1.40 p.m.	0.75	12:55 p.m.	1:07 p.m.	.02	.09	.43	.52											
Walla Walla, Wash.	2, 14, 16, 24, 30			T.														T.			
Washington, D. C.	3–4	8:02 p.m.	3:20 a.m.	2.33	11:55 p.m.	12:37 a.m.	.83	.18	.25	.43	.65	.80	.90	.99	1.06	1.10					
	12	11:07 a.m.	12:55 p.m.	1.34	11:31 a.m.	12:21 p.m.	.08	.15	.22	.23	.24	.44	.57	.60	.70	.94	1.09				
	30	4:30 a.m.	6:45 a.m.	1.13	5:05 a.m.	7:09 a.m.	.06	.08	.16	.27	.32	.33	.34	.45	.68	.74	.81	.91	1.06		
Wichita, Kans.	17	3:22 p.m.	6:20 p.m.	0.94	3:43 p.m.	4:15 p.m.	.07	.11	.18	.20	.28	.53	.65	.70							
	23	D. N. a.m.	5:35 a.m.	1.13	2:58 a.m.	3:19 a.m.	.01	.11	.34	.57	.69	.73									
	26	D. N. a.m.	D. N. a.m.	0.71	1:49 a.m.	2:08 a.m.	.01	.14	.32	.55	.62										
Williston, N. Dak.	19			0.27														.26			
Wilmington, N. C.	3	9:55 a.m.	12:25 p.m.	1.74	9:59 a.m.	11:38 a.m.	.01	.16	.40	.45	.45	.45	.46	.46	.46	.65	.85	1.14	1.49	1.68	
	27	11:05 a.m.	1:20 p.m.	1.05	12:28 p.m.	1:00 p.m.	.17	.13	.25	.28	.40	.63	.80	.83							
Winnemucca, Nev.	31			0.08														.04			
Wytheville, Va.	1			0.28														.28			
Yankton, S. Dak.	22	4:05 p.m.	5:50 p.m.	0.50	4:32 p.m.	4:38 p.m.	.03	.43	.44												
Yellowstone Park, Wyo.	14	6:20 p.m.	10:00 p.m.	0.82	6:37 p.m.	7:16 p.m.	.01	.10	.19	.30	.39	.45	.50	.55	.60						

* Self-register not working. † Record partly estimated. ‡ No precipitation occurred during month.

TABLE III.—*Data furnished by the Canadian Meteorological Service, August, 1915.*

Stations.	Pressure in inches.			Temperature.						Precipitation.		
	Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Inches.	*Inches.*	*Inches.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.												
Sydney, C. B. I.	29.95	29.99	+0.04	61.9	−1.4	70.9	52.9	83	40	4.92		
Halifax, N. S.	29.89	29.99	+.03	64.6	+1.0	73.9	55.2	87	43	8.18		
Yarmouth, N. S.	29.91	29.98	+.01	61.0	+0.8	68.3	53.8	77	42	2.92		
Charlottetown, P. E. I.	29.93	29.97	+.03	64.3	0.0	72.3	56.3	82	42	2.24		
Chatham, N. B.	29.95	29.97	+.04	65.2	+2.0	75.5	54.8	88	38	2.64		
Father Point, Que.	29.91	29.93	+.02	56.3	+0.7	64.6	48.0	72	38	3.86		
Quebec, Que.	29.65	29.97	+.04	64.3	+1.2	72.5	56.1	86	38	3.08		
Montreal, Que.	29.76	29.96	+.01	66.7	+0.3	74.8	58.6	87	45	2.46		
Stonecliffe, Ont.	29.38	29.98	+.02	62.3	−0.9	72.6	52.0	88	35	6.27		
Ottawa, Ont.	29.70	30.02	+.06	63.1	−1.7	71.0	55.2	84	40	7.57		
Kingston, Ont.	29.67	29.98	.00	65.1	−1.9	72.1	58.1	85	41	5.89		
Toronto, Ont.	29.56	29.91	−.08	66.2	+0.2	74.4	58.1	88	40	8.13		
White River, Ont.	29.69	29.99	+.03	55.8	−0.6	70.7	40.8	86	21	1.99		
Port Stanley, Ont.	29.33	29.97	−.03	65.2	−0.7	73.2	57.2	84	37	7.20		
Southampton, Ont.	29.27			61.8	−2.0	68.4	55.2	78	39	4.12		
Parry Sound, Ont.	29.28	29.96	−.02	63.2	−0.3	72.4	53.9	86	37	4.07		
Port Arthur, Ont.	29.32	30.03	+.07	61.0	+1.5	71.2	50.9	89	34	3.11		
Winniped, Man.	29.20	30.02	+.08	66.3	+0.1	81.8	50.8	93	32	0.13		
Minnedosa, Man.	28.25	30.03	+.09	62.7	+3.3	78.2	47.2	90	26	1.15		
Qu'Appelle, Sask.	27.77	29.98	+.05	65.2	+3.7	80.0	50.1	95	35	1.12		
Medicine Hat, Alberta.	27.68	29.90	−.02	73.2	−2.5	88.8	57.7	97	48	0.20		
Swift Current, Sask.	27.43	29.95	+.02	67.0	+3.0	82.6	51.3	94	38	0.76		
Calgary, Alberta.	26.43	29.88	−.03	65.4	+6.0	80.5	50.4	88	46	0.68		
Banff, Alberta.	25.48	29.98	+.07	60.2	+3.9	76.6	43.7	84	38	1.47		
Edmonton, Alberta.	27.68	29.92	.00	65.4	+6.6	79.3	51.5	87	43	3.24		
Prince Albert, Sask.	28.41	29.94	+.02	63.4	+4.5	75.0	51.9	86	32	0.30		
Battleford, Sask.	28.27	29.97	+.06	69.0	+6.4	84.9	53.0	95	38	0.22		
Kamloops, B. C.	28.72	29.98	+.07	71.6	+3.0	86.9	56.4	96	50	1.30		
Victoria, B. C.	29.75	30.00	−.01	62.0	+3.3	70.1	53.9	88	49	0.04		
Barkerville, B. C.	25.68	29.92	+.02	56.8	+0.5	70.1	43.6	77	36	2.47		
Hamilton, Bermuda.	29.92	30.08	−.02	80.2	+0.6	85.9	74.5	88	70	4.88		

Chart I. Hydrographs of Several Principal Rivers, August, 1915.

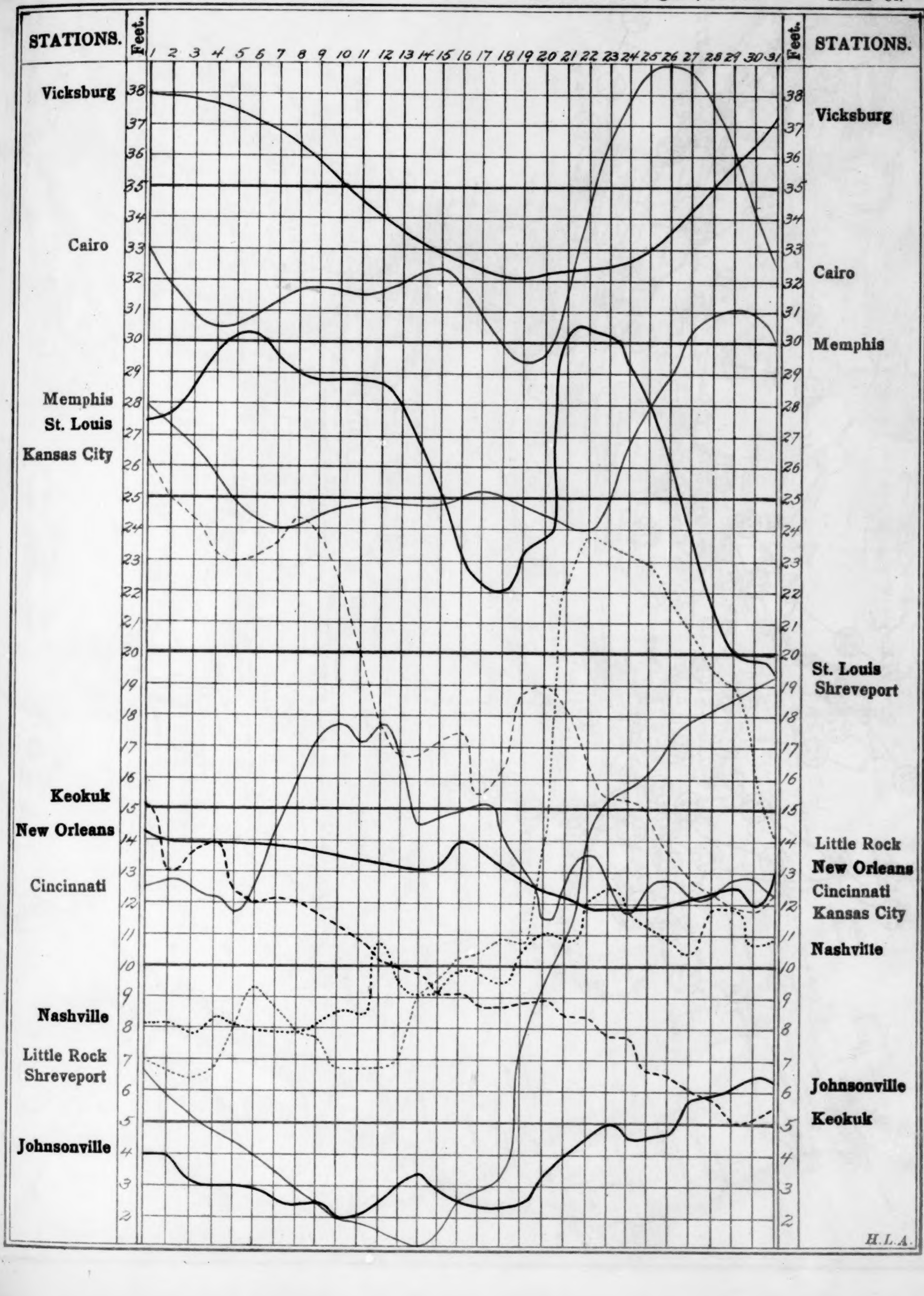


Chart II. Tracks of Centers of High Areas, August, 1915.

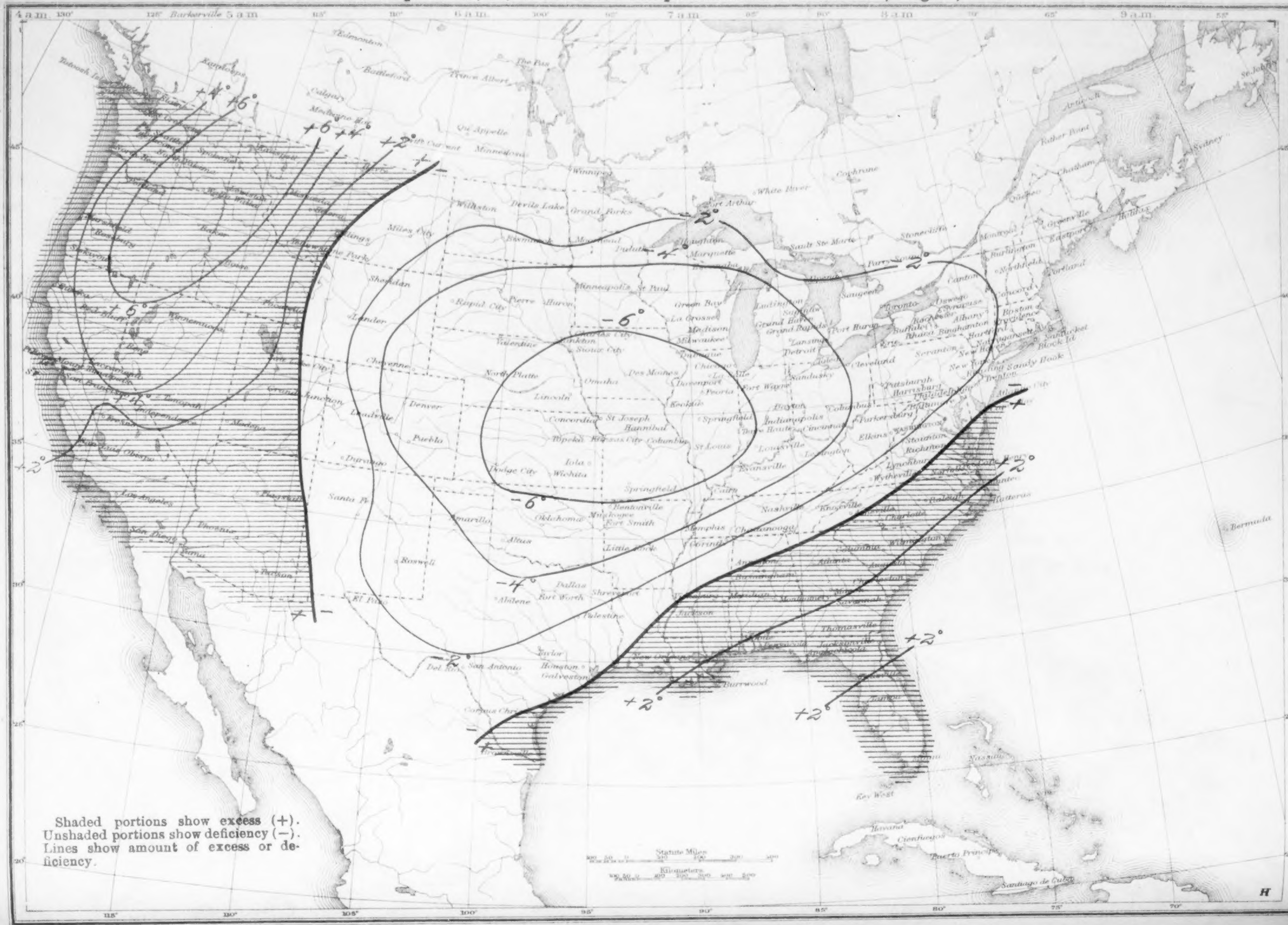
(Plotted by R. H. Weightman.)

Chart III. Tracks of Centers of Low Areas, August, 1915.

(Plotted by R. H. Weightman.)

Chart III. Tracks of Centers of Low Areas, August, 1915.
(Plotted by R. H. Weightman.)

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, August, 1915.



Shaded portions show excess (+). Unshaded portions show deficiency (−). Lines show amount of excess or deficiency.

Chart V. Total Precipitation, Inches, August, 1915.

Chart V. Total Precipitation, Inches, August, 1915.

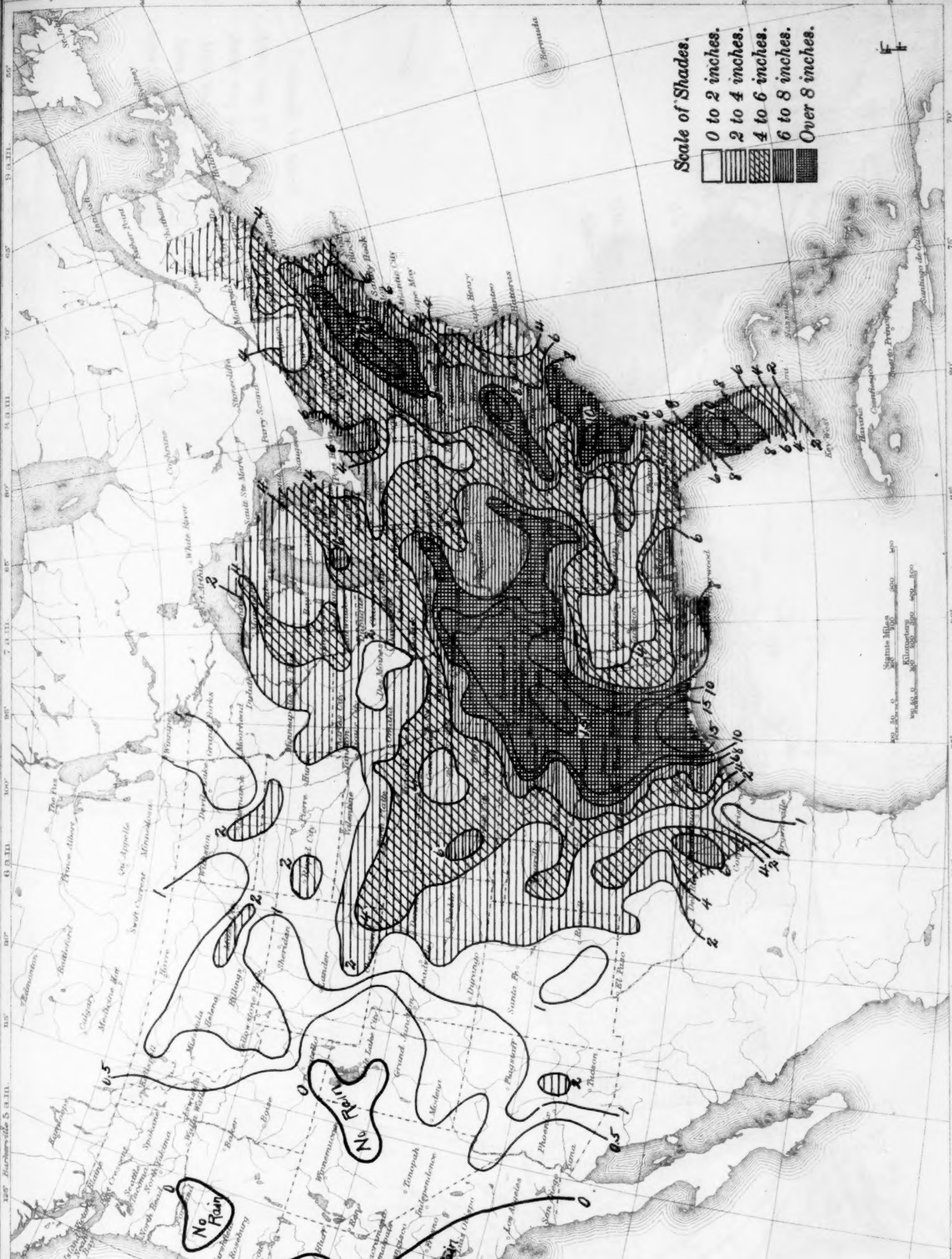


Chart VI. Percentage of Clear Sky between Sunrise and Sunset, August, 1915.

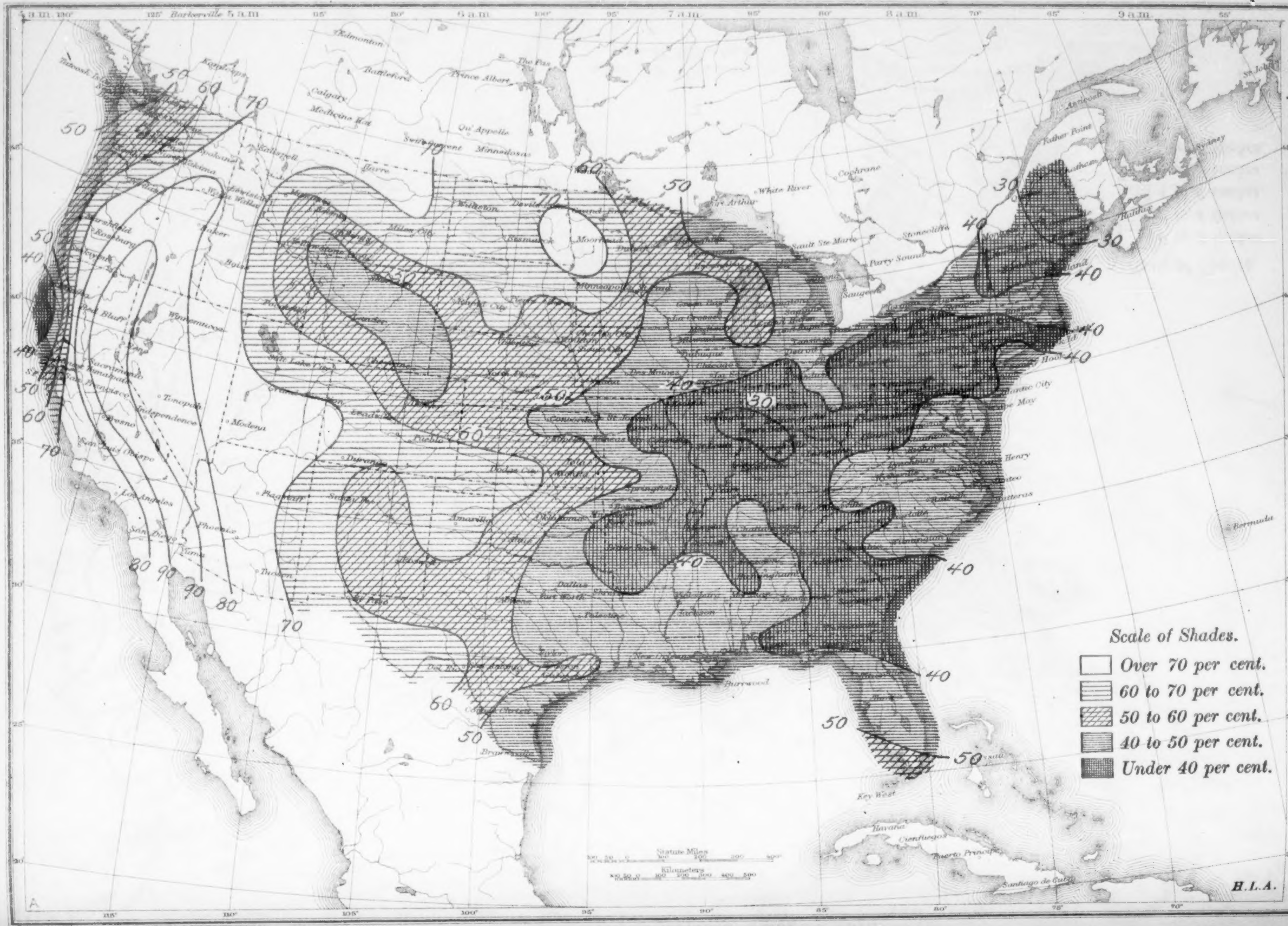


Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, August, 1915.

Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, August, 1915.

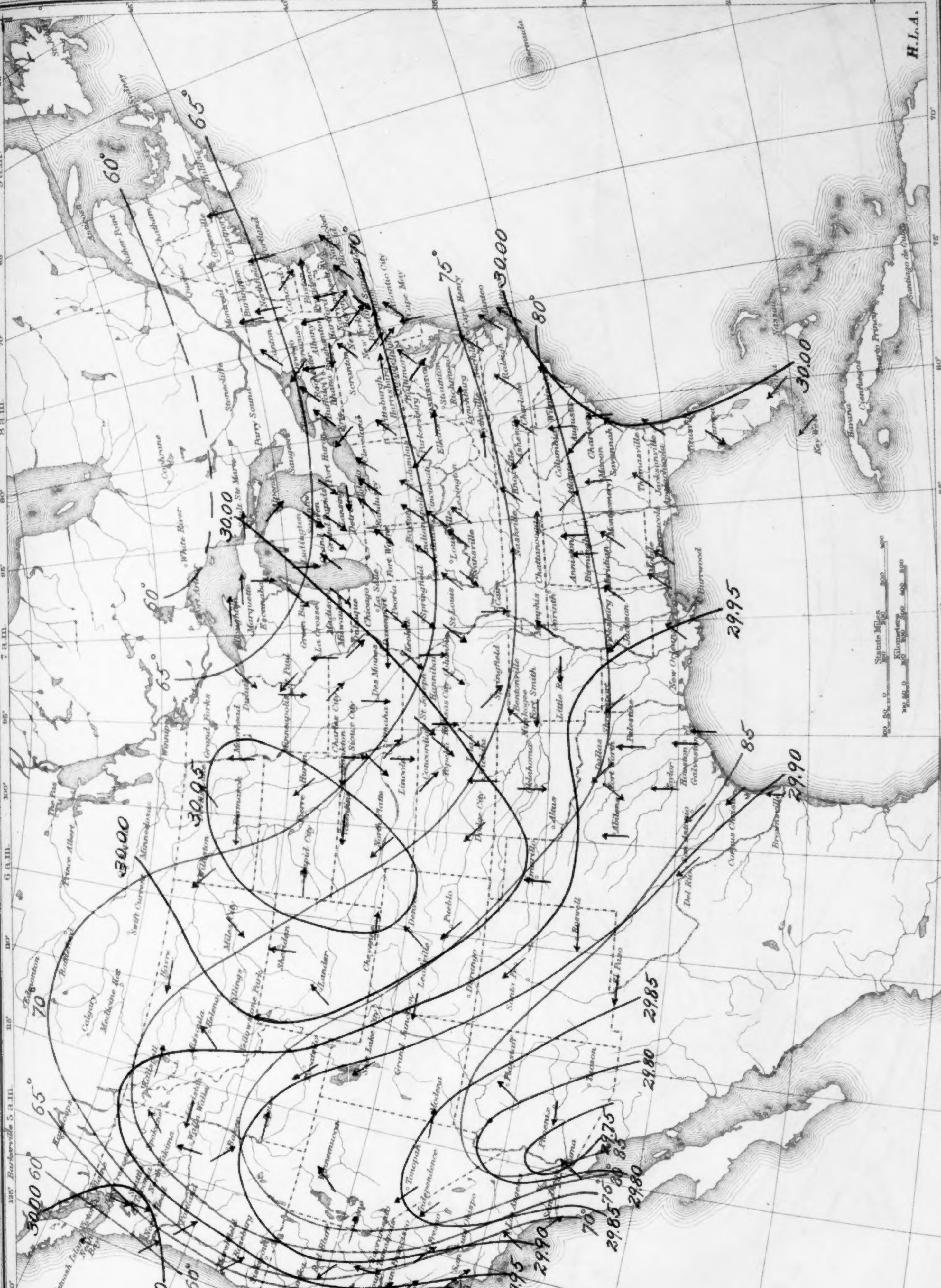


Chart IX. Means of Meteorological Data for North Atlantic Ocean, August, 1914.

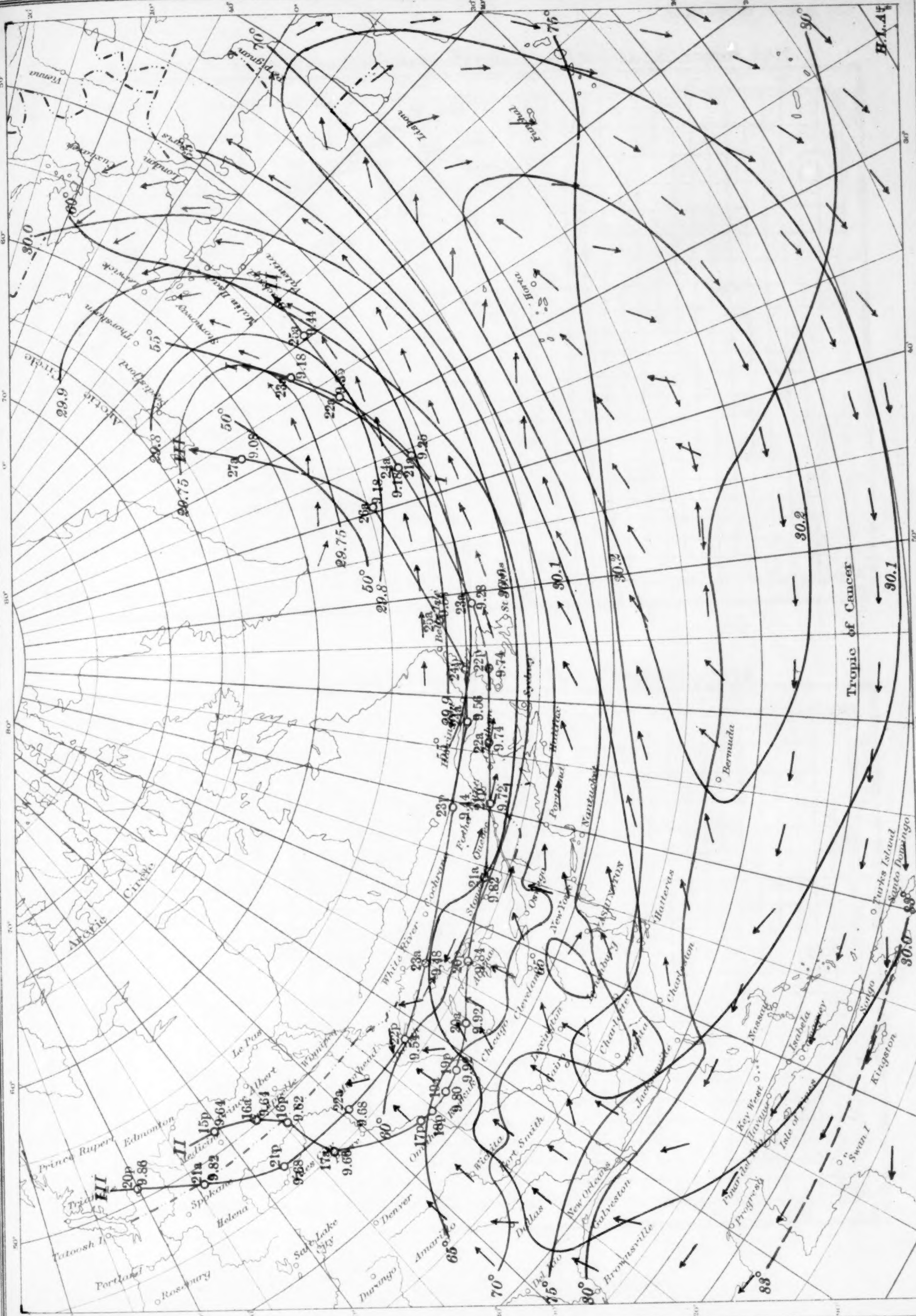
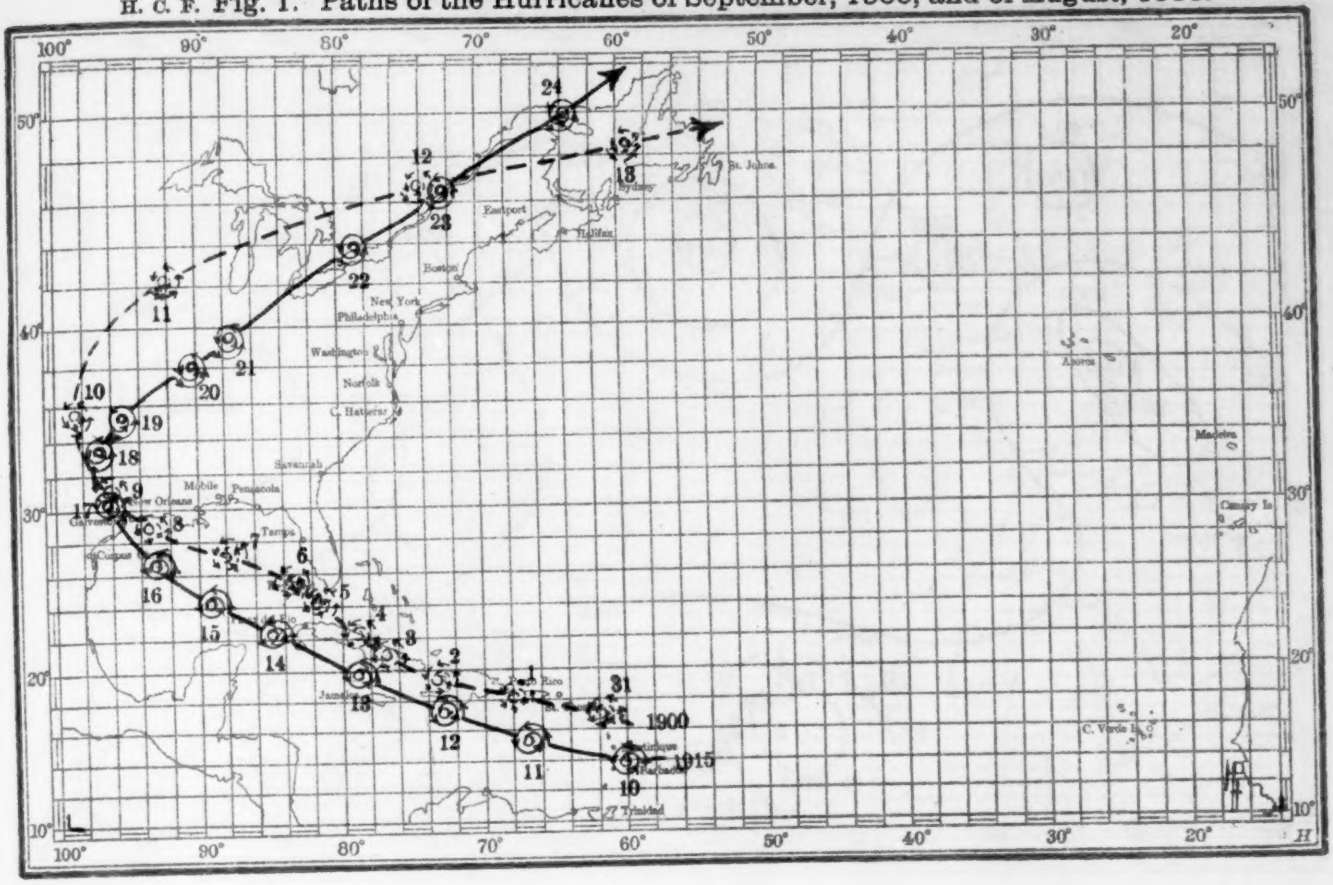
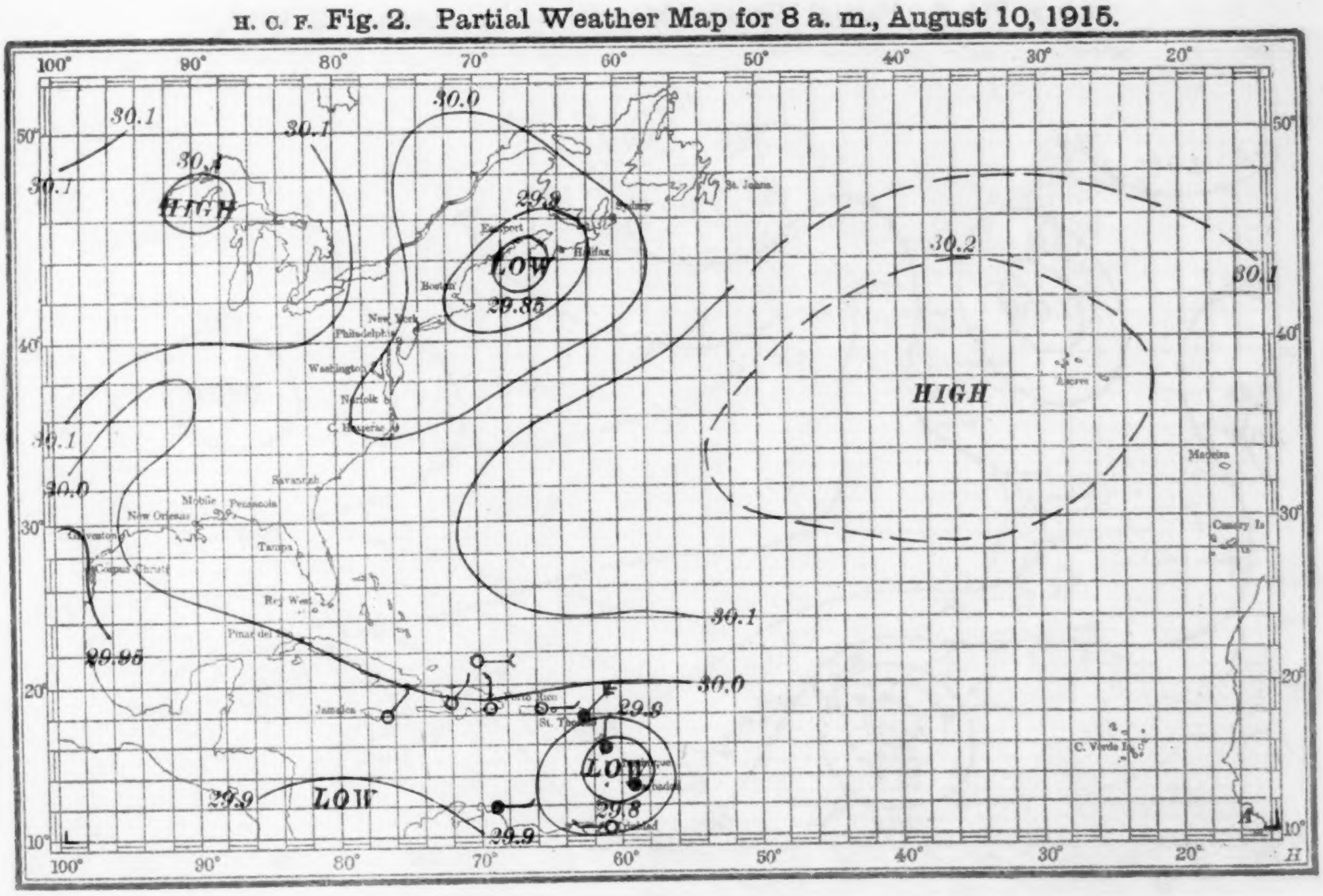


Chart IX. Means of Meteorological Data for North Atlantic Ocean, August, 1914.

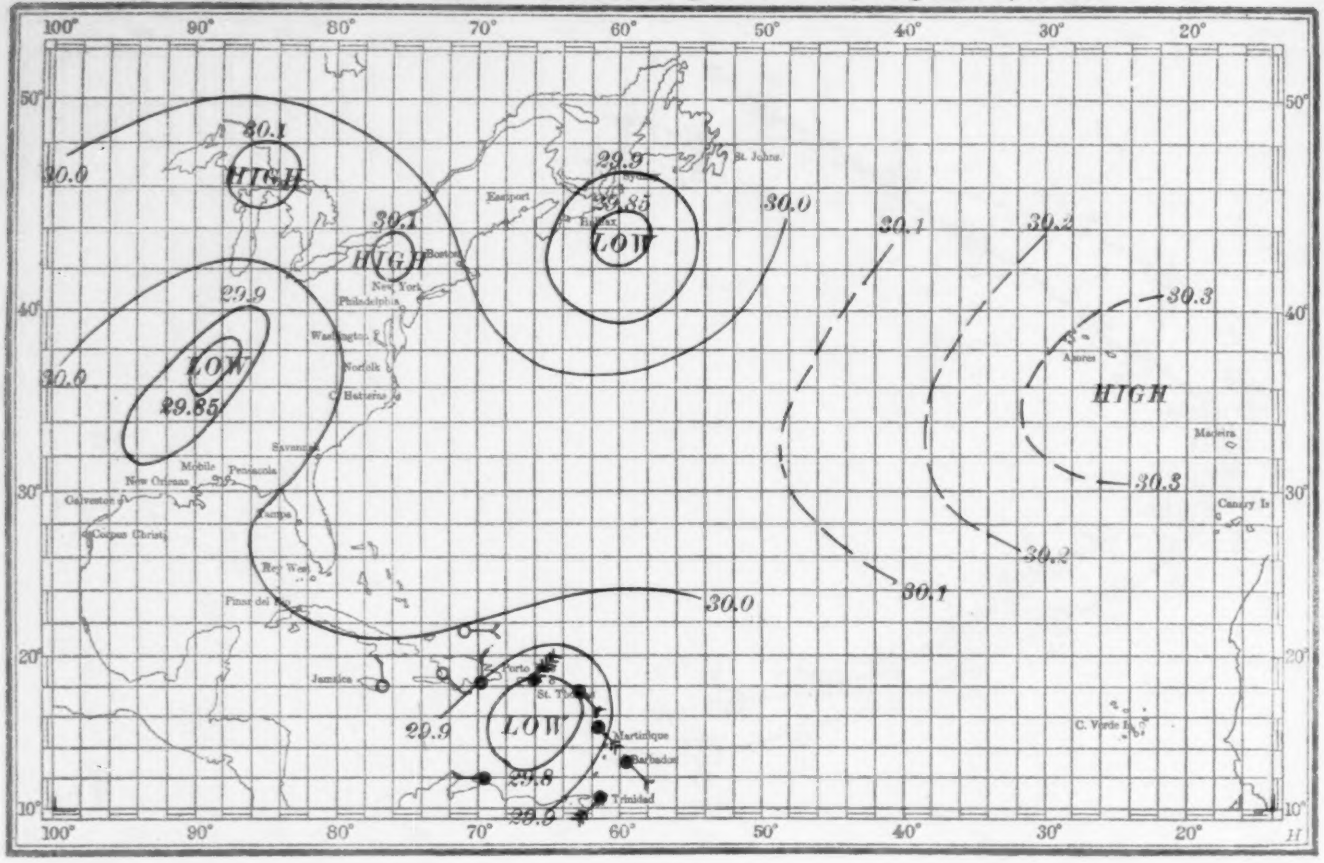
H. C. F. Fig. 1. Paths of the Hurricanes of September, 1900, and of August, 1915.



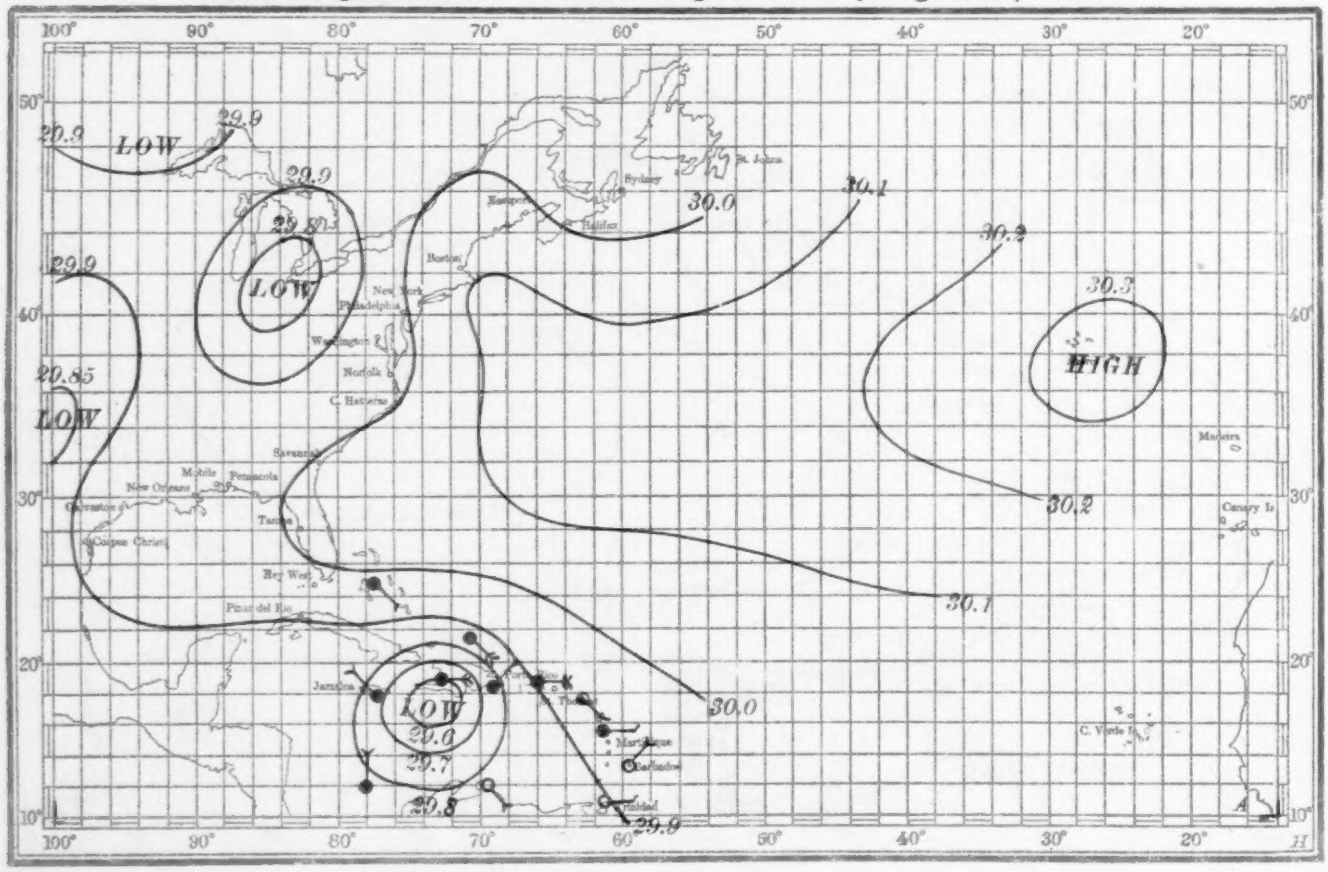
H. C. F. Fig. 2. Partial Weather Map for 8 a. m., August 10, 1915.



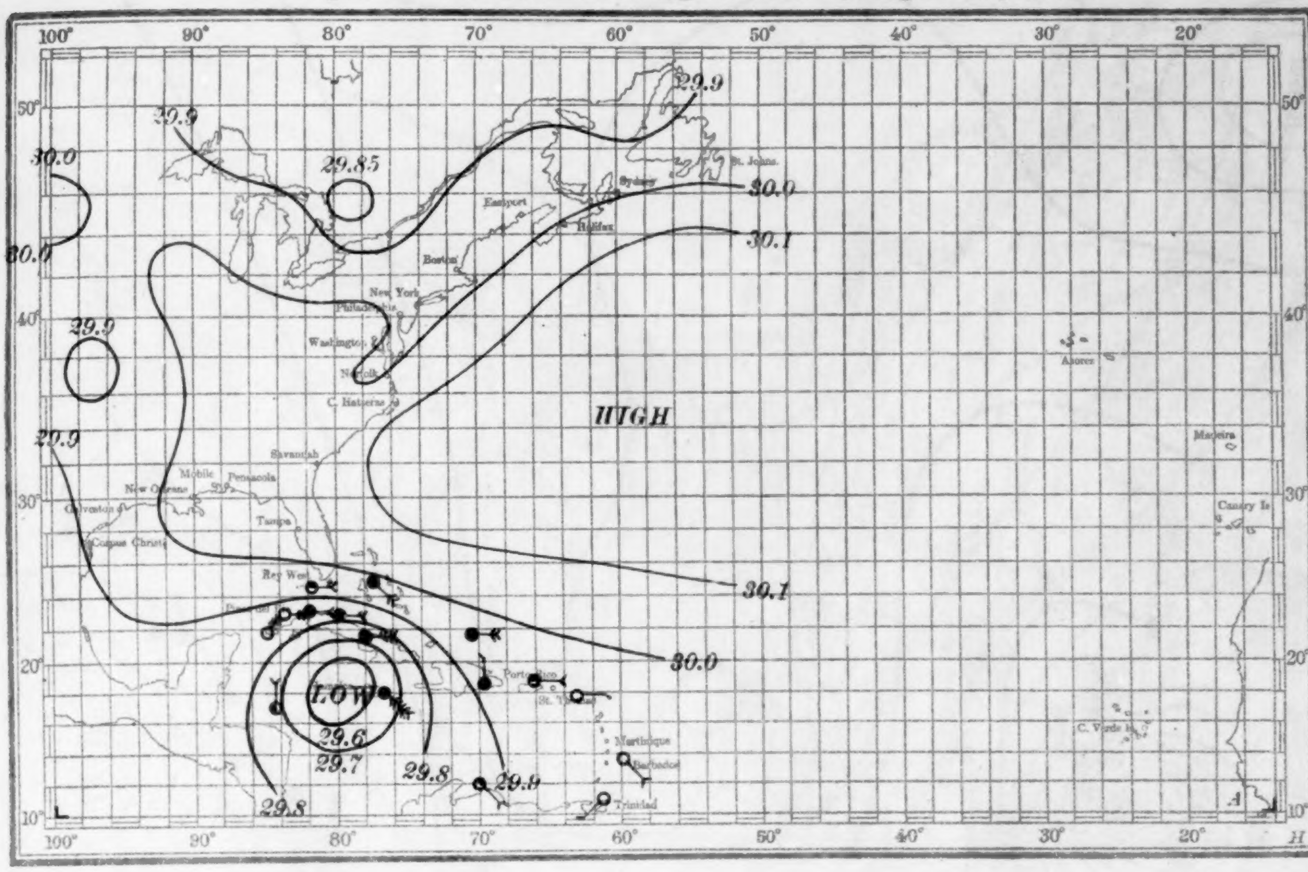
H. C. F. Fig. 3. Partial Weather Map for 8 a. m., August 11, 1915.



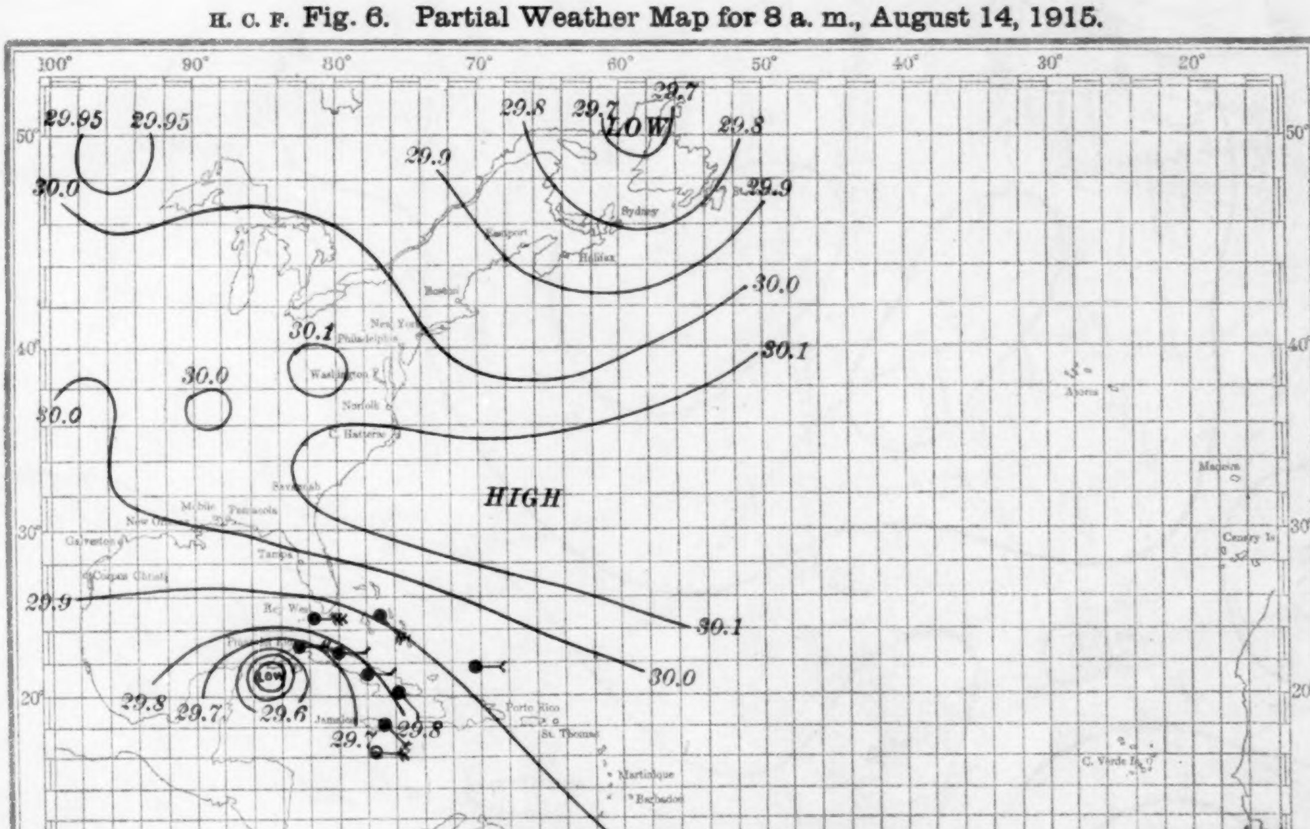
H. C. F. Fig. 4. Partial Weather Map for 8 a. m., August 12, 1915.



H. C. F. Fig. 5. Partial Weather Map for 8 a. m., August 13, 1915.



H. C. F. Fig. 6. Partial Weather Map for 8 a. m., August 14, 1915.

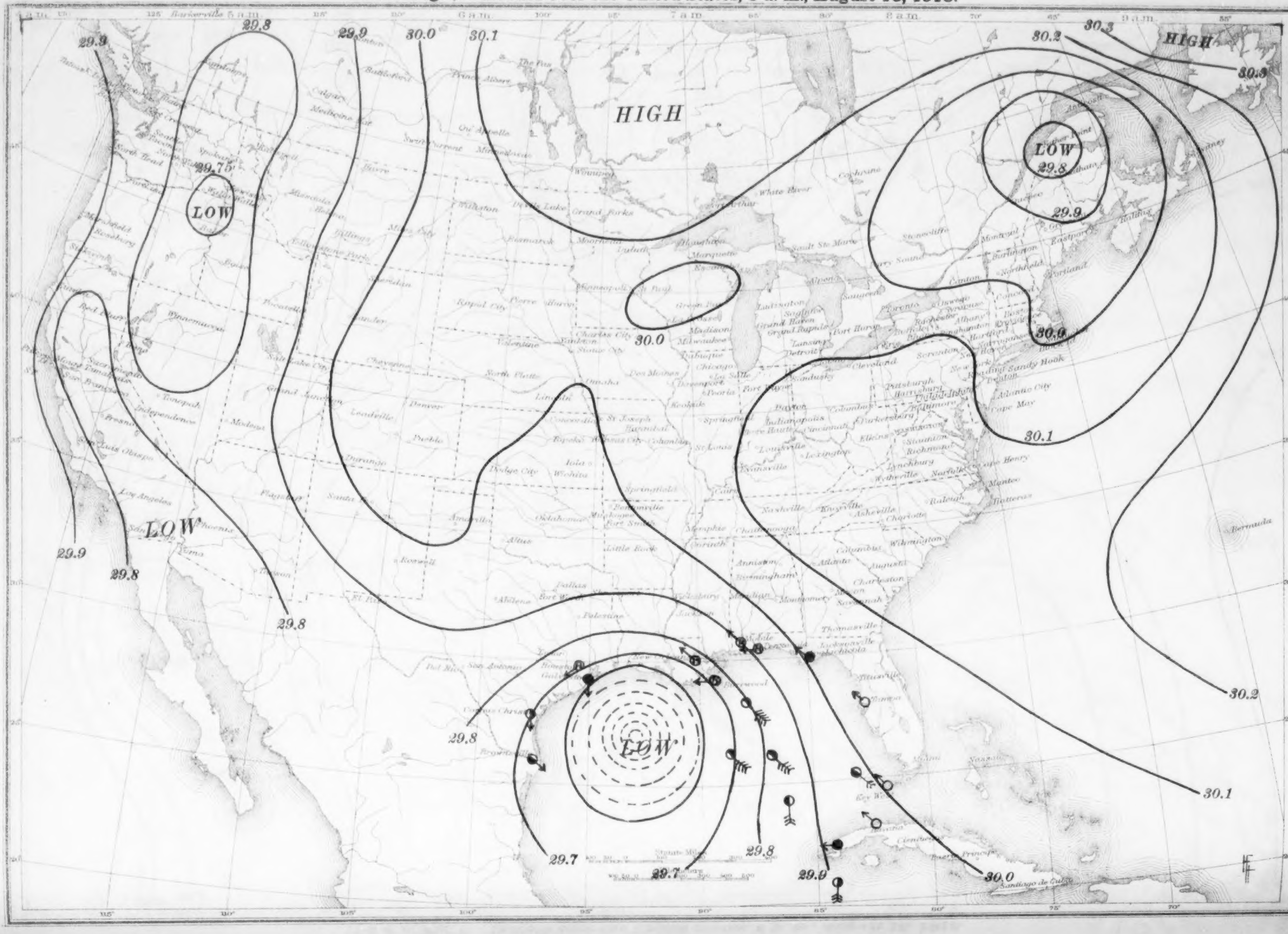


H. C. F. Fig. 7. Isobars over the United States, 8 a. m., August 15, 1915.

H. C. F. Fig. 8. Isobars over the United States, 8 p. m., August 15, 1915.

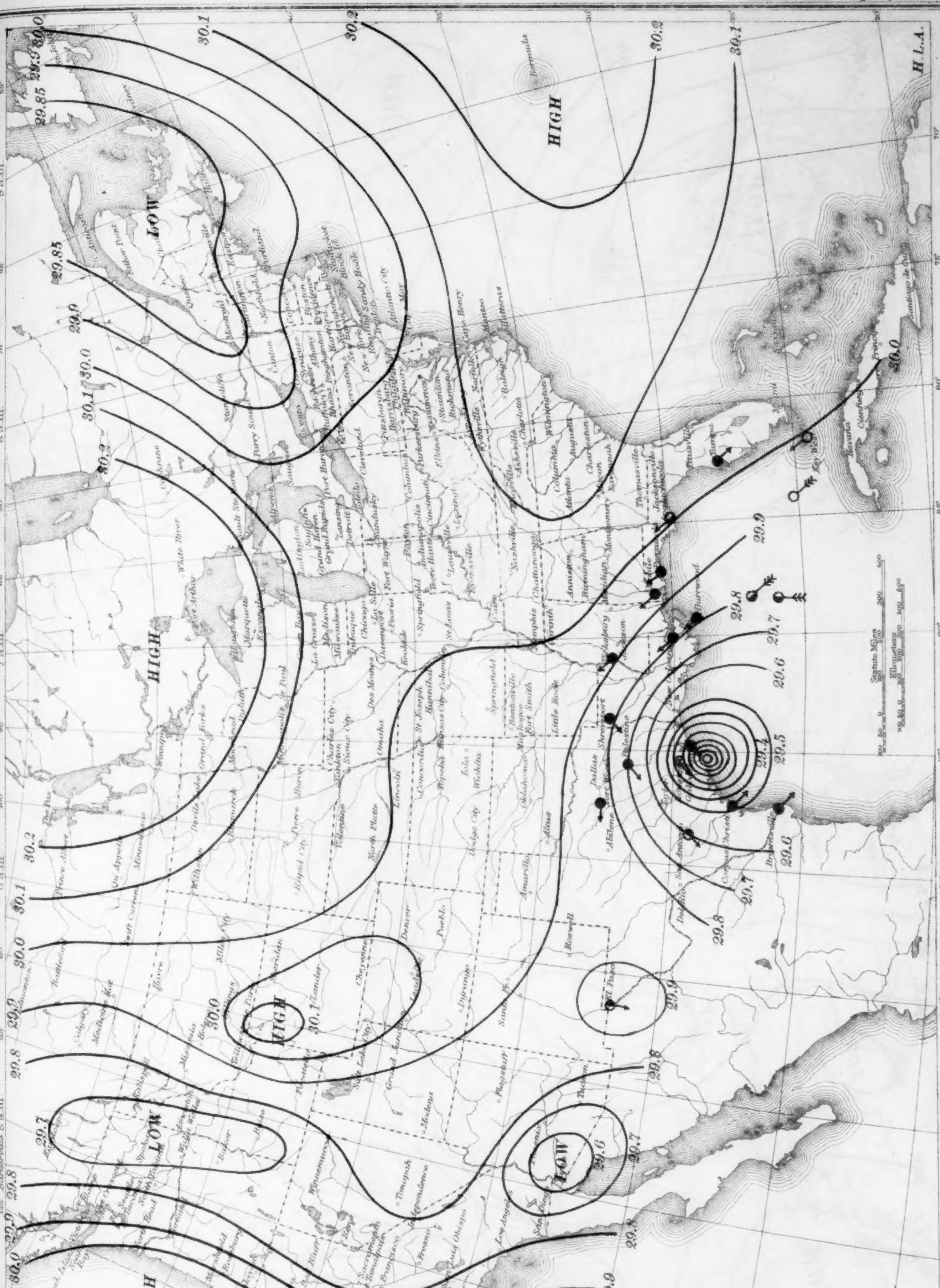
H. C. F. Fig. 8. Isobars over the United States, 8 p. m., August 15, 1915.

H. C. F. Fig. 9. Isobars over the United States, 8 a. m., August 16, 1915.

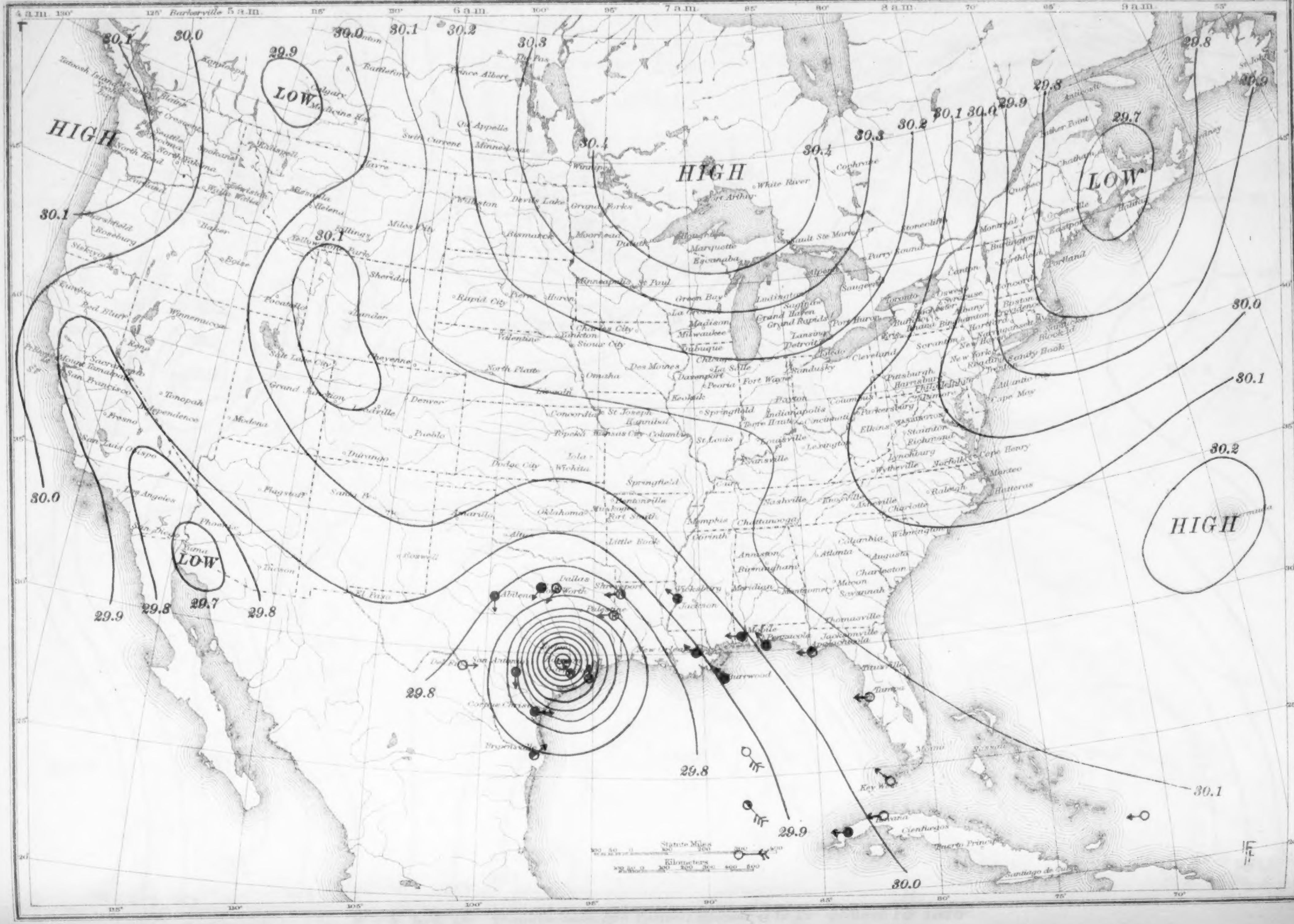


H. C. F. Fig. 10. Isobars over the United States, 8 p. m., August 16, 1915.

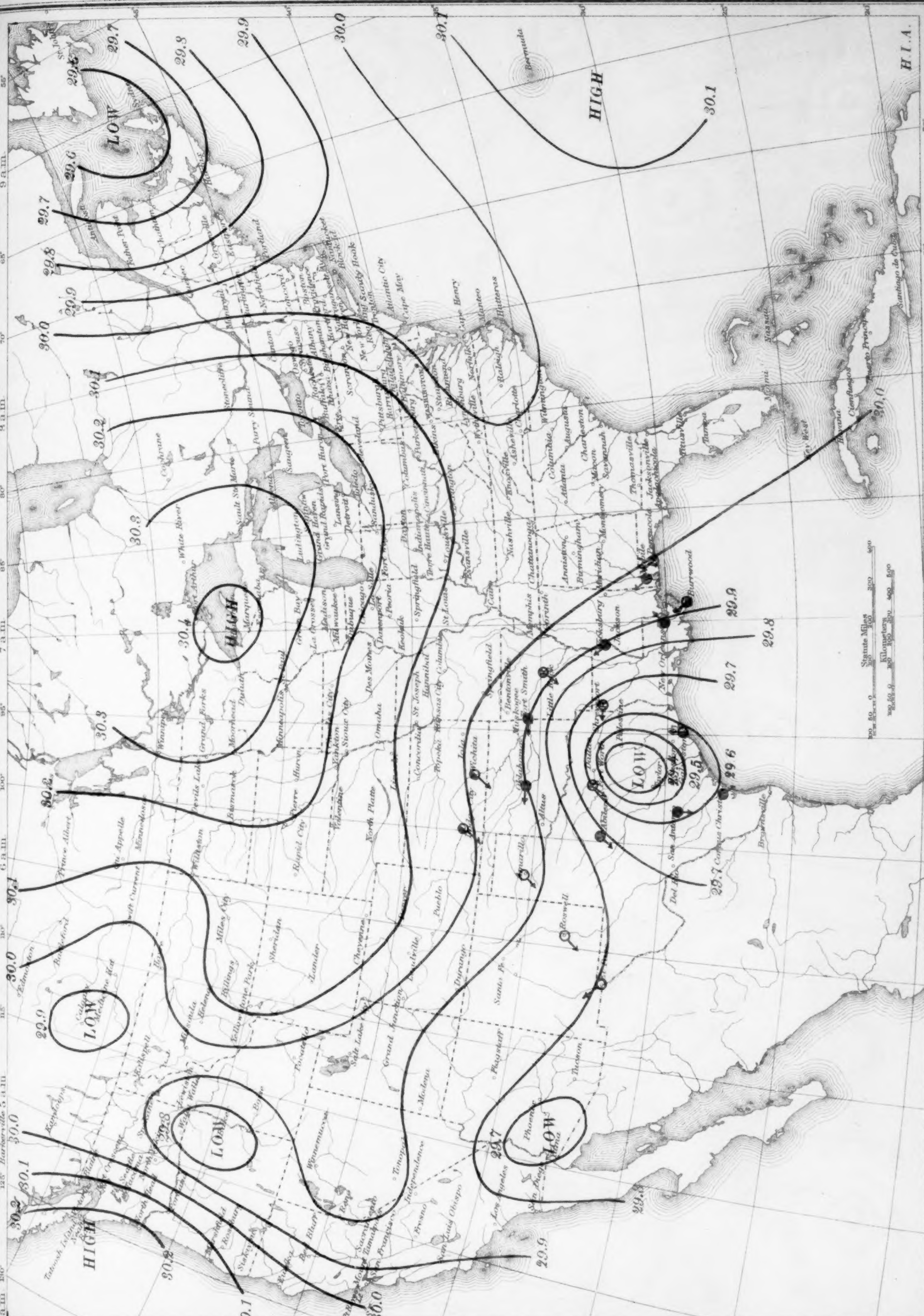
H. C. F. Fig. 10. Isobars over the United States, 8 p. m., August 16, 1915.



H. C. F. Fig. 11. Isobars over the United States, 8 a. m., August 17, 1915.



H. C. F. Fig. 12. Isobars over the United States, 8 p. m., August 17, 1915.



H. C. F. Fig. 12. Isobars over the United States, 8 p. m., August 17, 1915.